‘The Emotional Wardrobe’:
A Fashion Perspective on the Integration of Technology and Clothing

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Abstract

Since the Industrial Revolution, fashion and technology have been linked through the textile and manufacturing industries, a relationship that has propelled technical innovation and aesthetic and social change. Today a new alliance is emerging through the integration of electronic technology and smart materials on the body. However, it is not fashion designers who are exploiting this emerging area but interaction design, performance art and electronic and computing technologists. 'The Emotional Wardrobe' is a practice-based research project that seeks to address this imbalance by integrating technology with clothing from a fashion perspective. It aims to enhance fashion's expressive and responsive potential by investigating clothing that can both represent and stimulate an emotional response through the interface of technology.

Precedents can be found in the work of other practitioners who merge clothing design with responsive material technology to explore social interaction, social commentary and body responsive technology. Influence is also sought from designers who investigate the notion of paradoxical emotions. A survey of emotion science, emotional design, and affective computing is mapped onto a fashion design structure to assess if this fusion can create new 'poetic' paradigms for the interaction of fashion and technology. These models are explored through the production of 'worn' and 'unworn' case studies which are visualised through responsive garment prototypes and multi-media representations.

The marriage of fashion and technology is tested through a series of material experiments that aim to create a new aesthetic vocabulary that is responsive and

emotional. They integrate traditional fashion fabrics with material technology to enhance the definition of fashion. The study shows that the merger of fashion and technology can offer a more personal and provocative definition of self, one which actively involves the wearer in a mutable aesthetic identity, replacing the fixed physicality of fashion with a constant flux of self-expression and playful psychological experience.

The contribution of the research consists of: the integration of technology to alter communication in fashion, a recontextualisation of fashion within a wider arena of emotion and technology, the use of technologies from other disciplines to materialize ideas and broaden the application of those technologies, and the articulation of a fashion design methodology.

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Introduction

Background

> What we are talking about here is a...revolution - one which will require the electronics industry to 'think emotionally'...we can not expect the fashion industry to adapt itself to technology. Rather the technology industry will have to learn how to deal with fashion.[1]

With the advent of new 'wearable' electronic and material technologies an innovative union between fashion and technology could satisfy the fashion industry's continual search for novelty. To date, however, it has been electronics and computing that have investigated technology for the body. When fashion has embraced 'wearable' technology it has merely utilised clothing as a carrier of entertainment and communication systems, adding increased functionality. Few researchers have exploited technology for aesthetic purposes, or explored the social and interactive potential that this could offer. A field is now emerging that seeks to address this balance, consisting of artists, technologists, and interaction designers. The Emotional Wardrobe is situated within this realm and asks whether fashion can offer a different perspective.

Adjacent to this change is a growing interest in emotion. Neuroscience is seeking to map the emotional brain to understand how it operates and how it affects our cognitive functions. Interaction designers are manipulating social interactions via technology, to heighten emotional experience. Within the fields of product and industrial design,

emotional design is endeavouring to find a formula to 'design' emotions, adding value to products and creating meaningful connections with users. Some of these designers are investigating intangible needs and creating provocative and dark interactions with electrical products. There is a recognition that technology needs to become more emotional and that it might be interesting to design products and experiences that elicit paradoxical emotions. In a society that is increasingly mediated by personal technologies and remote communications, could technology be used in clothing to create more meaningful face-to-face interactions or to imbue clothing with personalities? My own research investigates how fashion can merge the fields of wearable technology and emotion research to produce garments that contribute to both disciplines by using responsive aesthetics to mediate emotional exchanges between the wearer, the viewer and society.

Research Proposal

Might material technology, sensors and computing be integrated with fashion aesthetics to enhance and extend fashion's capacity to communicate? This project investigates the evolution of an Emotional Wardrobe that responds to the wearer or the viewer, creating an emotional and aesthetic dialogue. It consists of Unworn and Worn garments that are experiments in the merger of clothing and technology and asks whether such a merger could be used to communicate and evoke emotions?

The Unworn garments propose that clothing which is left unworn could nevertheless react to human presence. They are 'animated' by human characteristics, fears and

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[1] *New Nomads: An Exploration of Wearable Electronics by Philips*, ed by Stefano Marzano, (Rotterdam: 010 Publishers, 2000), p.7.

fantasies and they seek to provoke paradoxical emotions in the viewer. They ask whether expressive and responsive qualities in clothing would enrich our emotional connection to garments or prove uncomfortable and disturbing? Emovere (the Worn garment) uses the physiological response of the wearer to control its aesthetic as an expression of human emotion. It asks whether a dynamic exchange might result, between the technology and the wearer, and the dress and society.

Objectives

- *To make working prototypes that combine existing and emerging material and computing technology with fashion design.*
- *To investigate the impact of technology on the fashion design process.*
- *To work collaboratively between the fields of fashion, computing, electronics and material science.*
- *To alter the definition of fashion communication to include responsive aesthetics that communicate and elicit emotions in ways that anticipate future cultural change.*

Collaboration

To answer the research questions and achieve the objectives my research looked to the fields of affective computing, electronics and material science. Due to the technical nature of this work, electronic and computing expertise were sought from industry, academia and an independent specialist. They were engaged to implement the technology or act as advisor to the research. I assumed the role of creative director and fashion designer, by initiating the concepts and the use of technology, directing the

development of the work and constructing the garments. This research is not a joint project and the practice is easily distinguished from the technology that has been developed to create it. The nature of the collaborative relationship and process is documented throughout the thesis.

Role Of Practice

This research project was both practice-based and practice-led. The practice operated both as the stimulus for gathering information and as part of the research methodology to test and evaluate it. The practice outcomes set the agenda for further practice. In this way, practice fed back into practice. By being practice led, information gathering becomes part of the design process, a series of 'What would happen if ?' questions. The information was assessed critically rather than being simply assimilated before integration but was understood through and in relation to the practice. This process informed the methodology.

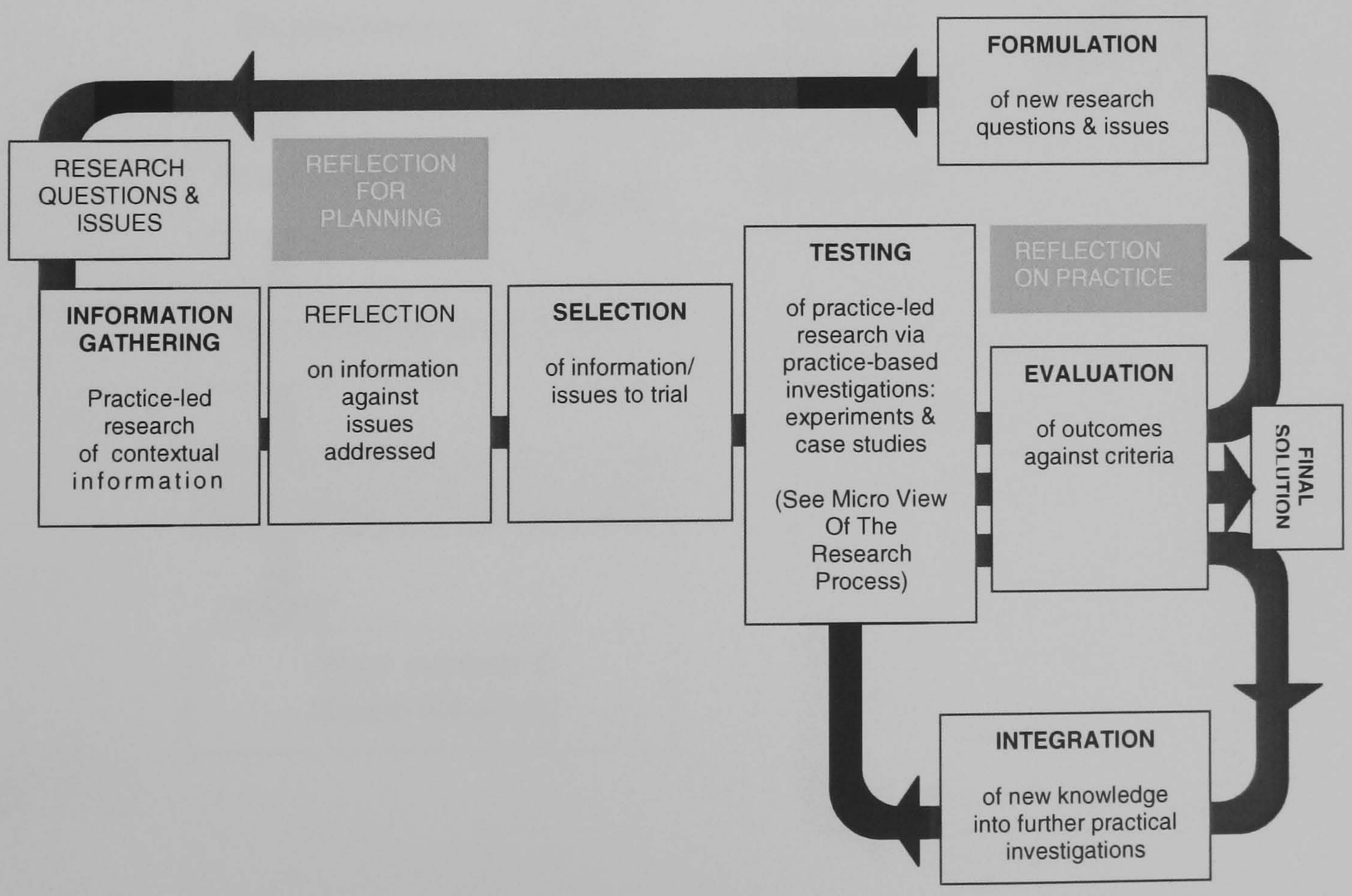
Methodology

Methodology in fashion is rarely addressed as a separate subject. It is understood as part of the "natural" creative process of garment design, exploration and manufacture. In 'The Emotional Wardrobe', the process was explicitly observed, recorded and examined, thereby revealing and documenting the underlying methodology of the practice. An iterative fashion design methodology emerged which resulted in emotion experiments and reflective case studies.

Macro View Of Practice-based Research Process

The research process for 'The Emotional Wardrobe' followed a sequence of information gathering, reflection and selection events which were then tested and evaluated by the practice. Initially the process was stimulated by a series of research questions and issues that looked to technical and contextual information to provide design influences and tools. The information was selected for its relevance to the research and its ability to move the practice along. The design process relied not only on newly acquired information but also on personal experience and past knowledge to inform decisions, direction and to evaluate the practice. The practice was used to test and understand the information, the resulting outcomes were evaluated against conceptual, aesthetic and technical criteria. They prompted either a return to the beginning of the process and the identification of new questions and issues to be addressed, or were incorporated as new knowledge onto further practical investigations or finished works of practice (Fig. I).

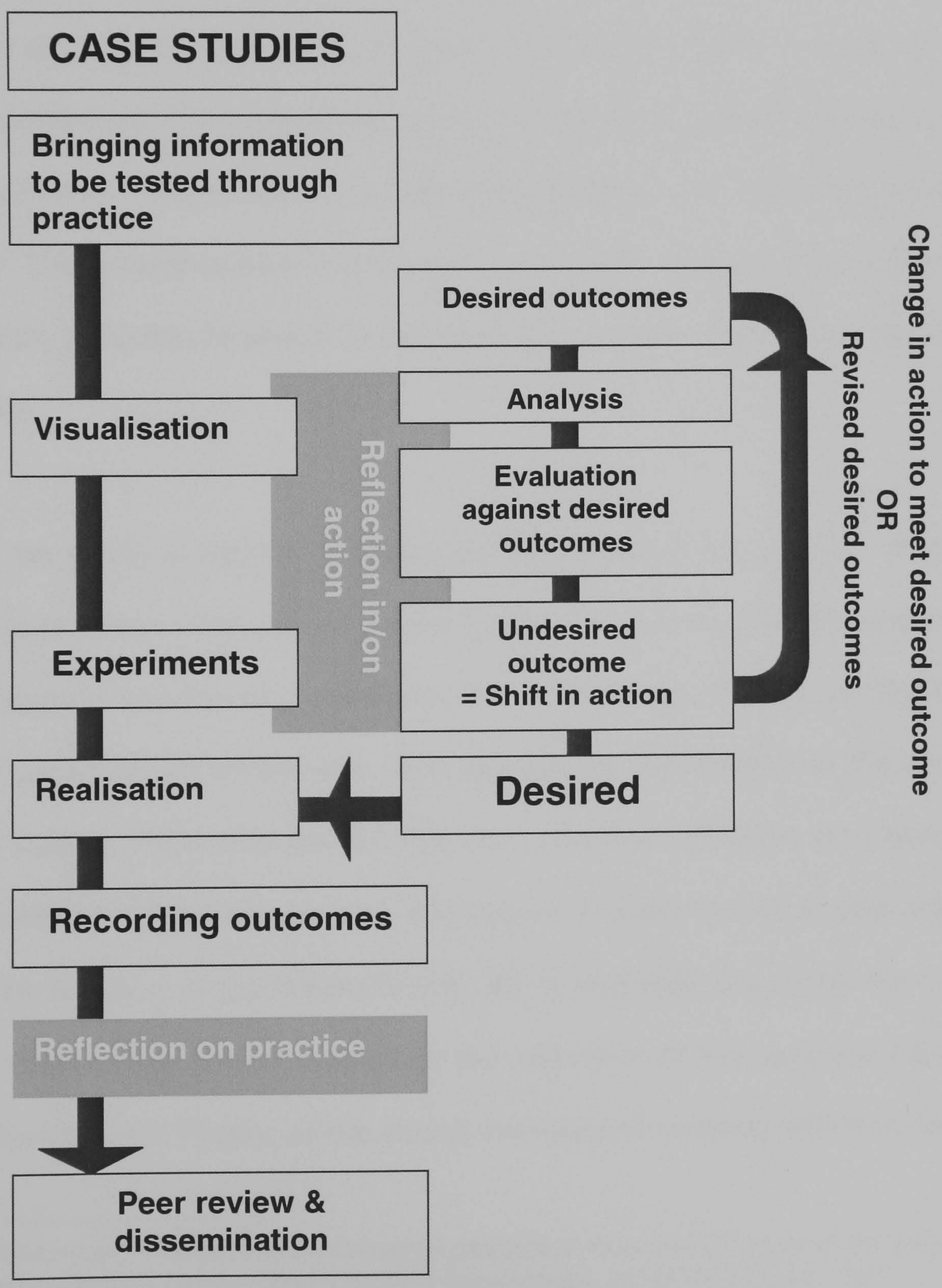
Fig. I. **Macro View Of The Research Process**



Micro View of Practice-based Research Process

The case studies make sense of the information through visualisation, experimentation and realisation. If this process is blocked, i.e. if technical problems stop a visualisation becoming an experiment, or if the outcome of one stage is unsuccessful, reflection and a shift in action is employed until the desired outcome is reached. If a line of enquiry is disregarded, the practice returns to information gathering to resume progress (Fig. II).

Fig.II. **Micro View Of Research Process**



Reflection

Reflection is used to gain insight into what is occurring in the practice. It operates in two ways, as reflection **in** action and practice and reflection **on** action and practice. Scrivener characterises reflection **in** action and practice as, 'driven by the unexpected', and reflection **on** action and practice as 'the desire to learn from experience'. [2] Reflection **in** action is stimulated by undesired or unexpected outcomes in the practice, which cause the practitioner to consider the work and make an adjustment to progress it. It is an evaluation made against the tacit knowledge of the practitioner who imagines the current situation against her or his past experience in order to make to make an informed judgement. The experience of the practitioner can be furthered by entering into a conversation with the work, i.e. deferring judgement and allowing the materials to talk back. [3] These insights lead to another line of enquiry to move the practice along. In this research, 'reflection **in** action' progressed the research in the experiments and the case studies.

Reflection **on** action is used to consider the outcomes of the practice when a break occurs in its progress. This can be a short break in the work cycle (the end of the day) or a purposeful evaluation of the practice at the end of the practice. In 'The Emotional Wardrobe' reflection **on** action was used to evaluate the practice in the experiments and case studies. Reflection **on** practice also informed reflection for planning which was implemented before the research had begun, in order to look at past practice and map out the direction of the research (Fig. III). It was also used after the information gathering stage of the project to analyse the relevance of the data and plan the next steps of the research. Finally, at the end of the research project, reflection for planning

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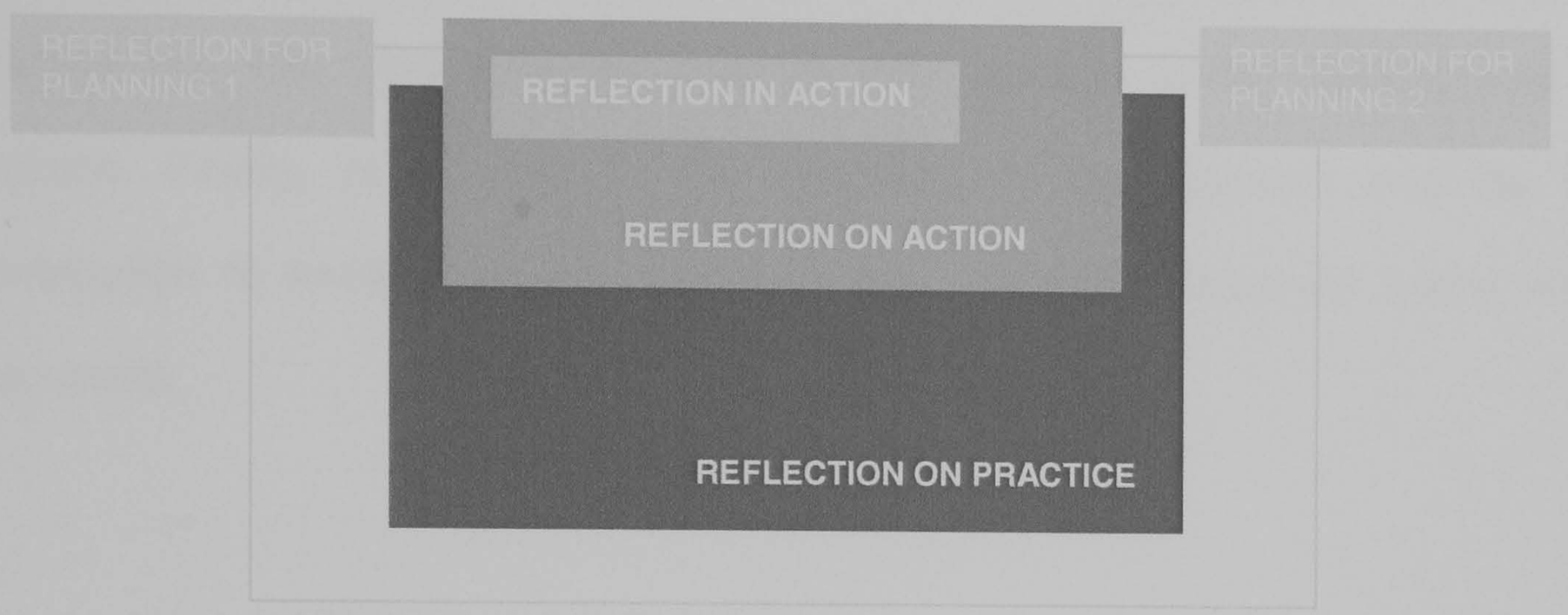
[2] Stephen Scrivener,' Characterising Creative-production Doctoral Projects in Art and Design', *International Journal of Design Sciences and Technology,* 10 (2002), 25-44, (13)
[3] Donald A Schön, *The Reflective Practitioner: How Professionals Think in Action* (Great Britian: Arena, Ashgate Publishing, 1991), p.101.

was used to plan future directions for the practice. The reflection phases of this research are demonstrated in the chapters of this thesis.

Fig. III. **Types Of Reflection During The Research Process**



Key to the location of reflection in thesis

- Reflection for Planning 1 – Chapter 1 & 2, Context and Practice Review
- Reflection In Action – Chapter 3, Case studies
- Reflection On Action – Chapter 3, Case Studies
- Reflection On Practice – Chapter 4, Outcomes, Analysis & Evaluation
- Reflection For Planning 2 – Chapter 5, Summary & Conclusions

Chapter 1, the Context Review, charts the themes and questions that have shaped the research, against a background of fashion and technology. It places fashion and technology alongside product and interaction design and affective computing, in an emotional design context. Chapter 2, The Practice Review, looks at contemporary practitioners in the field of fashion and technology. It uncovers an emergent field comprising the work of artists, technologists and interaction designers but is largely devoid of fashion design. Chapter 3, The Case Studies, documents my own work. It

shows how the work functions both individually and as a totality, reviewing both its successes and its failures. Chapter 4, Outcomes, Analysis and Evaluation, analyses and evaluates the case studies against a knowledge-building table that is cross-referenced with feedback from the dissemination of the work. At the beginning of the research a methodological model was proposed. This is assessed against the methodology that emerged and any changes noted. The methods employed in the practice are also considered to illustrate their function in the development of the practice. Finally, in Chapter 5, the objectives of the research and the original contribution to knowledge are assessed, and the implications for future work are discussed.

CHAPTER 1

Context Review

Fashion And Technology

Fashion: Definitions

Clothing, dress and fashion are all intrinsically linked but to distinguish one from the other is problematic as the boundaries merge and are sometimes unclear. There are many different approaches to the study of clothing, dress and fashion: anthropology, art history, dress history, cultural studies, social psychology and sociology. As Joanne Entwistle notes:

> Far from clearly employing one or other term [for fashion or dress] and defining it precisely, there is a considerable degree of confusion in the various bodies of literature with many authors employing a number of different terms, often using them interchangeably. A review of the literature illustrates the fact that there is no consensus on the definition and use of these words and no agreement on precisely what phenomena they describe.'[4]

Although, some fashion theorists have even argued that fashion – as opposed to dress - resists logic and cannot be interpreted in any straightforward way, clarification is necessary.[5] Fashion has been linked to a complex system of social, economic and

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[4] Joanne Entwistle, *The Fashioned Body: Fashion, Dress and Modern Social Theory*, (Cambridge: Polity Press, 2000), p.41.

[5] For example: 'pure fashion, logical fashion ... acts out, meaning, plays meaning': Roland Barthes, *The Fashion System*, trans. by Mathew Ward and Richard Howard (Berkeley: University of California Press, 1990), p.289. See too: Elizabeth Wilson, *Adorned in Dreams: Fashion and Modernity*, 2nd edn(London: I.B.Tauris, 2003), who finds many existing explanations of fashion inadequate, in her chapter 3, 'Explaining It All Away'; and Caroline Evans and Minna Thornton, who argue that fashion 'often puts up a very successful barrier

cultural conditions. Entwistle argues that these conditions are found, 'in societies where social mobility is possible; it has its own particular relations of production and consumption; it is characterised by a logic of regular and systematic change'.[6] Elizabeth Wilson states, 'Fashion, in a sense *is* change'.[7] Fashion is transient; in today's western society it denotes a rapid shifting of styles. [8]

Fashion has been argued to be a reflection of the times[9] and a form of communication and self-expression.[10] However as with most interpretations of fashion these definitions are ambiguous. Fred Davis makes sense of the ambiguity of fashion by saying that sometimes the meaning is clear and at other times it is suggestive, resembling music with its, 'emotions, allusions and moods'.[11] Davis also suggests that fashion's ambiguity is further fuelled by our own crisis of identity; our anxiety to communicate the right message about ourselves, which causes ambivalence.[12]

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against interpretation', in 'Fashion, Representation, Femininity', *Feminist Review*, 38, (1991), 48-66 (p.48).

[6] Entwistle, pp. 47-48.

[7] Wilson, p.3.

[8] Most commentators have differentiated fashion from dress as consisting of rapid style change: Rene Konig, 1973; Joanne Finklestein,1991; Fred Davis, 1994; Jennifer Craik, 1993 and Wilson, 2003.

[9] Zeitgeist theorists have argued that fashion change has been linked to political and economic change, a so-called 'mirror of the times'. Other theories of 'emulation' in society and changing erogenous zones for women have also attempted to explain the reasons for change. These views are seen as simplistic by some theorists who argue that other social forces such as age, race, class and gender and our daily decisions about how we wished to be seen affect fashion change, (Entwistle, 2000; Wilson, 2003 and Davis, 1994).

[10] Semiotic theorists address fashion as a series of non-verbal signs based on language, whilst Lurie, goes as far as suggesting that fashion has its own 'grammer' and 'vocabulary'. See, Alison Lurie, *The Language of Clothes* (London: Heinneman, 1981), p.4. This would suggest that the wearer and the viewer understand all fashion communications but fashion is not so easily prescriptive. See Malcolm Barnard, *Fashion as Communication,* (London and New York: Routledge, 1996).

[11] Fred Davis, *Fashion, Culture and Identity*, (Chicago: The University of Chicago Press, 1994), p.3.

[12] Davis, pp.21-29.

Fashion And Identity

Fashion is more than utilitarian protection or comfort; it is also psychological, as many fashion historians have argued.[13] Fashion is able to bring us psychological benefit through our emotional response to what we wear, how we look and how we are perceived.[14] The main element of this psychological impact is the construction and the communication of the self, which, as Davis suggests, is complex in today's society where fashion is constantly changing and playing on the ambivalence of social roles. Wilson, argues that, 'If the self, in all its aspects, appears threatened in modern society, then fashion becomes an important – indeed vital – medium in the recreation of the lost self or 'decentred subject'.' [15] Wilson describes the post-modern world as 'fragmented' and recognises that this characteristic is reflected in the 'confusion' of mixed styles presented by fashion. Within this framework she suggests that fashion can act as a way for the individual to fix their identity by the adoption of one style.

Conversely, fashion can be used creatively to play with identity. Anne Boultwood and Robert Jerrard propose that the speed at which styles are now created, adopted and discarded emphasises the importance of individualism in modern society.[16]

There appears to be a paradox between wanting to find comfort in an external display of constant identity and the need to show individualism by rapid transformation. This is further complicated by the need to conform or differentiate ourselves from others in

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13 Many early twentieth-century theorists related the function of fashion to, for example, modesty, protection or social display (Veblen, 1899; Flugel, 1930; Laver 1969 and Bell, 1992) However more recent theorists have rejected such simplistic explanations in favour of a more complex analysis of the relationship of fashion to subjectivity, over and above utilitarian function (Konig, 1973; Finkelstein, 1991; Craik, 1993; Davies, 1994; Barnard, 1996; Entwistle, 2000; Entwistle and Wilson, 2001.)

14 For example, see Ann Hollander, *Seeing Through Clothes*, (New York: Avon Books, 1980), for a discussion of the way that comfort in fashion is psychological more than it is physical.

15 Wilson, *Adorned in Dreams* p.122.

society.[17] Boultwood and Jerrard, among others, categorise this phenomenon as ambivalence, which they argue has always been a 'part of our psychological make-up' rather than being explained by the nature our post-modern society.[18]

Ambivalence in fashion suggests that a changing aesthetic identity could be beneficial by helping us to 'fit-in' or differentiate ourselves from others when necessary. Perhaps the integration of technology in fashion could provide the tools to express multi - faceted visions of self, building on the symbiotic relationship that fashion has always had with technology.

The Impact Of Technology On Fashion

Fashion and technology have always been linked through fabric and manufacturing processes and fashion change has been led as much by technological as by social and cultural change.[19] For example, the development of the Singer sewing machine in 1851 aided mass produced clothing and enabled a democratization of fashion. Historically there have been periods when production workers, consumers, commentators and designers alike have all been hostile to the changes that technological developments

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[16] Anne Boultwood and Robert Jerrard, ' Ambivalence and its Relation to Fashion and the Body', *Fashion Theory*, 4 (2000), 301-322 (p 307).
[17] Elizabeth Wilson, 'Fashion and the Postmodern Body',in *Chic Thrills :A Fashion Reader*, ed. by Juliet Ash and Elizabeth Wilson (London: Pandora Press, 1992), p6
[18] Anne Boultwood and Robert Jerrard, p.309. Also see p.311 for a useful diagram that charts many fashion theorists, their definition of ambivalence and the role that fashion plays in coping with it.

have afforded fashion.[20]

The 1960s were an exception that saw the development of synthetic fabrics and with them new opportunities to create concepts for fashion. Pierre Cardin, Andre Courrèges and Paco Rabanne embraced technology and were influenced by the idea of the 'Space Age'.[21] Rabanne made garments out of linked circles of metal, that resembled chain-mail (Fig.1. 1). Courrèges experimented with fabrics from areas such as sport and the army and used colour, in particular 'optical' white, to express optimism and purity (Fig.1. 2).[22] Cardin created simple, futuristic shapes that owed their inspiration to abstract art. He also created garments in 'Cardine', which allowed him to mold three-dimensional shapes into the surface of the garments (Fig.1. 3). This was a period of optimism for technology, fashion and the future, epitomized in Cardin's Cosmos range in 1966. The range was unisex and functional, comprising comfortable jersey tunics or pinafores for all the family. What is interesting about this concept is that although the public accepted some pieces of the ensemble, Cardin's aim was to invent clothes for 'the world of tomorrow', 'for a world that doesn't exist yet'.[23] In this way his vision can be compared to Utopian Dress, where clothing is designed with a non-existent society in mind.[24] The practice within 'The Emotional Wardrobe' could also be said to look to

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[19] Similarly, architecture and technology enjoy a dialogical relationship where one informs the other which can be seen as analogous to fashion and technology. See Peter Reyner Banham, *The Architecture of the Well-tempered Environment* (London: Architectural Press, 1969).
[20] Christopher Breward, *The Cultures of Fashion: A New History of Fashionable Dress* (Manchester: Manchester University Press, 1995), pp.145-163, shows how in the latter half of the 19th Century changes in the look of ladieswear coincided with technological developments. Notably, the introduction of aniline dyes and steel crinolines which provoked debate and dress reform. Sadie Plant, *Zeros and Ones* (London : Fourth Estate Limited, 1998), pp.14-15, discusses the development of the Jacquard loom and its incitement of Luddite rioters.
[21] In 1961 Yury Gagarin was the first man to go into space.
[22] See, Valérie Guillaume, *Courrèges*, Fashion Memoir (London: Thames and Hudson, 1998), pp 12-16
[23] Pierre Cardin, *Pierre Cardin: Past, Present, Future*, with an introductory essay by Valerie Mendes (London: Dirk Nishen, 1990), p10.
[24] See Aileen Ribeiro, 'Utopian Dress', in *Chic Thrills :A fashion Reader*, ed. by Juliet Ash and Elizabeth Wilson (London: Pandora Press, 1992), pp225-237, for a discussion of the tradition of utopian dress.

Fig.1. 1.
Paco Rabanne, *Chain Mail Suit* (1968),.
Source: Suzanne Lee, *Fashioning The Future* (2005).

Fig.1. 2.
André Courrèges (Autumn/Winter 1968-1969), presented a space age aesthetic made from sportwear fabrics.
Source: Valerie Guillaume, *Courrèges* (1998)

Fig.1. 3.
Pierre Cardin's (1960s), *Cardine* fabric enabled him to mould three-dimensional surface patterns.
Source:
http://www.pierrecardin.com

an imagined future but the future implications of technology on emotion that the practice uncovered are dystopian not utopian, questioning how fashion could help in world of technology and manipulated emotions.

Fashion And Technology Now

Jumping ahead to 2005, what influence has technology had on fashion and what might technology offer for the future? Fashion cycles have accelerated and 'fast fashion' now dominates the mass market. [25] Yet today technology has developed that has the potential to make fashion less disposable by adding value through increased fabric performance (although this has not yet altered the pace of fashion turnover). Much fabric innovation has originated from the sportswear industry. Mountaineering has come to the high street with the introduction of *Polar Fleece* and *Gore-Tex*, offering warm, breathable, wind and water resistant clothing.[26] The fabrics and footwear of athletes are also designed to dress the urban sportsman. Fabrics such as *Outlast* and *Schoeller-PCM* use phase-change technology to store excess heat and redistribute it to the body when it cools.[27] An intelligent trainer from Adidas, the *Adidas 1*, uses a sensor and microprocessor to take readings of changes in the environment and foot-position, adjusting the cushioning to provide optimum comfort and support (Fig.1. 4).[28] Adidas have also collaborated with the fashion designer Stella McCartney to produce a range

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[25] See Simona Segre Reinach, 'China and Italy: Fast Fashion versus Prêt à Porter. Towards a New Culture of Fashion', *Fashion Theory*, 9 (2005), 43-46 for a definition of fast fashion and Michelle Lee who comments that, 'Speed chic is the crack cocaine of fashion: cheap fast and addictive', Michelle Lee, *Fashion Victim* (New York: Broadway Books, 2003), p.34.

[26] See Gore-tex, http://www.gore-tex.com/ [accessed 10th July 2002]

[27] Phase –change fabrics contain a microthermal layer, which has microcapsules of paraffin wax (or a similar material that changes state in reaction to temperature change) embedded in its structure. The wax liquefies when the body heats up and becomes solid again when cold, releasing the stored heat. See, Outlast, http://www.outlast.com/ [accessed 5th February 2002] and Schoeller, http://www.schoeller-textiles.com/ [accessed 22nd May 2005].

[28] See Adidas 1 website, <http://www.adidas.com/campaigns/adidas_1/content/v2/adidas_1.asp?strCountry_adidasc...> [accessed 20th September 2005]

of sportswear to 'enhance your physical performance' and 'your physical appearance' (Fig.1. 5).[29] Adidas have also taken the fashion style/sportswear performance crossover further, by employing the fashion designer Yohji Yamomoto to create the *Y-3* range, a high fashion product with sportswear credentials (Figs.1. 6 and 1. 7).[30]

Textile technology also offers functional fabrics that respond to the body through the process of micro-encapsulation. They can be engineered to deliver perfume, body lotions, anti-cellulite treatments and even vitamin-C. Diani Irani, a textile research student at the Royal College of Art, produced a line of clothing called 'Clothes that Cure', which contained micro-encapsulated medicine and herbal remedies.[31] X-Static also provides antibacterial qualities in textiles by knitting silver threads into their fabric.[32] However, microencapsulated fabrics could soon be overtaken by nano-technology, which promises to engineer fabrics on an atomic scale, potentially creating both functionality and surface change. Companies such as Nano-tex are already developing fabrics that are crease resistant and water resistant. [33] All of these fabrics provide added wearer benefit through enhanced performance but they are not concerned with the surface design of the fabric to aid fashion styling.

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[29] See Adidas/ Stella Mc Cartney website, <http://www.adidas.com/campaigns/women/content/stella/fall2005/stella.asp?strCountry_asp> [accessed 20th September 2005]

[30] See Y-3 website, <http://www.adidas.com/y-3/> [accessed 20 September 2005]. Nike also understand their latest trainers are fashion items more likely to see the catwalk or the pavement than a running track., see 'Sneaker Chic', *Elle*, October 2005, pp.359-362 (Fig. 7).

[31] To create a microencapsulated fabric, droplets or particles of the active ingredient such as, body lotion are encased in a polymer shell and suspended in a carrier agent. The microcapsules can be sprayed, coated or dyed onto fabric and are activated by heat or abrasion when they are exposed to the body. See, just-style.com, 'Inside Story', *just-style.com.*(17th August 2001), <http://just-style.com/features_detail.asp?art=426&app=1> [accessed 24th August 2001]. The Japanese company Fuji Spinning Co Ltd have created the vitamin-C shirt that uses a chemical called pro-vitamin to provide the dose of vitamins. It changes to vitamin-C when it reacts to body heat and is subsequently absorbed by the body. See, <http://www.fujibo.co.jp/us/company/company1.html> [accessed 12th April 2005].

[32] See, X-static, http://www.x-static.com/ [accessed 10th July 2002].

[33] See, Nano-tex, < http://www.nano-tex.com/> [accessed 22nd August 2005].

Fig.1. 4.
Adidas, *Adidas 1*(2004), It also has LED's for extra design appeal!
Source: http://www.gizmodo.com/archives/adidas-1-selfadapting-shoes-015943.php

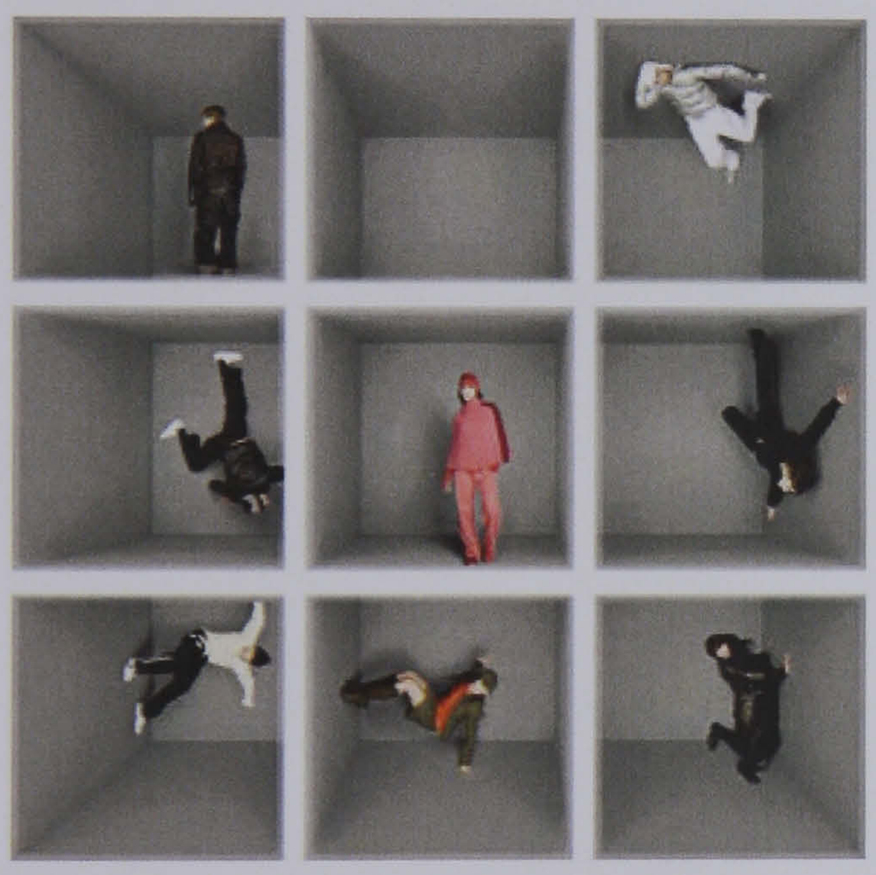

Fig.1. 6.
Yojhi Yamamoto, *Y-3* (2004), his collaborative ranges for Adidas, lead the Sport Style division, "Inspired by the future of sport and fashion". It is driven by fashion and uses mainly low-tech fabrics.
Source: http://www.adidas.com/Y-3/container.asp

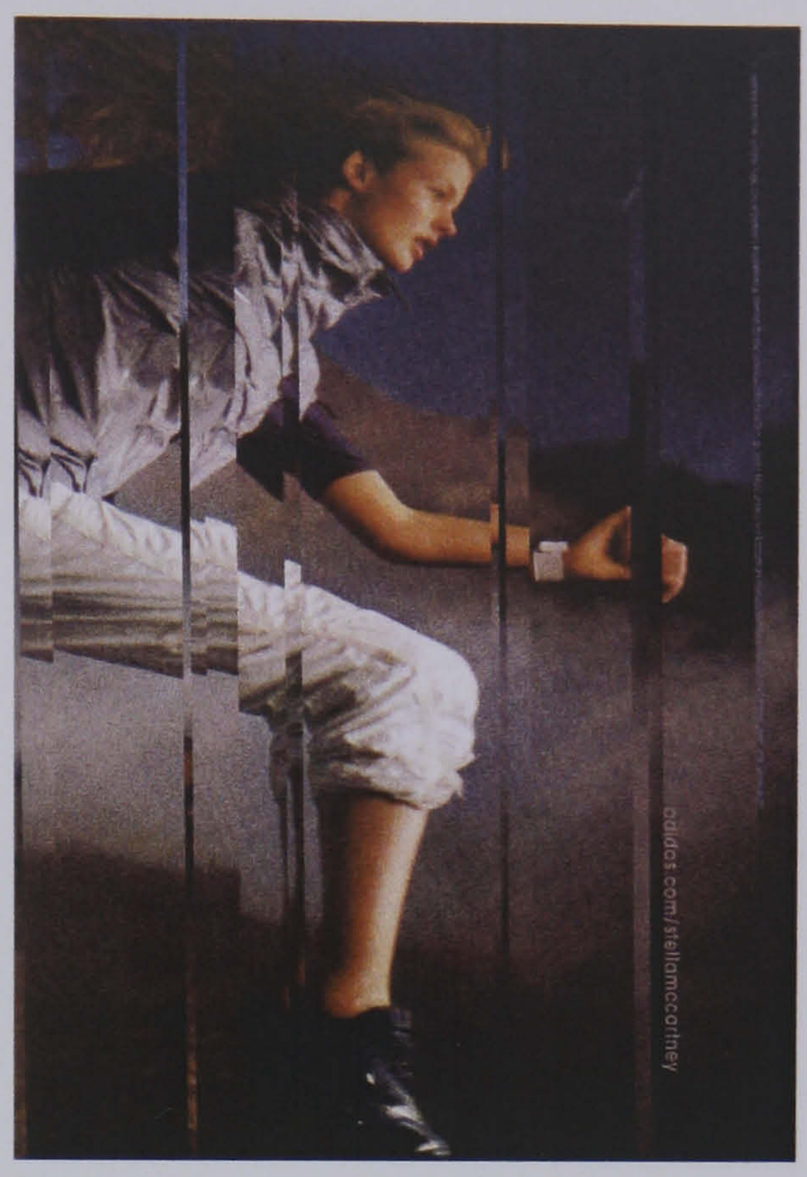

Fig.1. 5.
Stella McCartney for Adidas (2005), belongs to the Adidas Sport Performance division. It utilizes technical textiles and is to be worn for sport but has 'fashionable' styling.
Source: *Elle*, October, 2005.

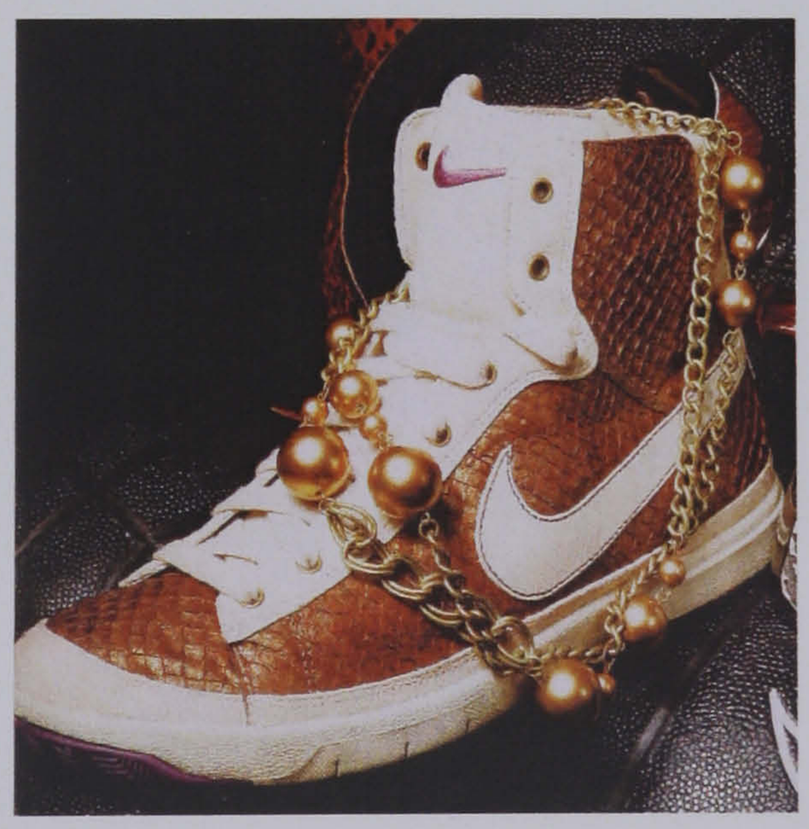

Fig.1. 7.
Elle, (October 2005) illustrates the collaboration between Nike and the couture shoemaker, Kurt Geiger. Source: *Elle*, October, 2005.

Fashion designers such as Helmut Lang and Donna Karan (DKNY line) use performance fabrics the same way as traditional fashion fabrics to enhance their design ranges. Issey Miyake's development of technological fabrics and processes are key to the aesthetics of his garments. *Pleats Please* is a range of clothing based on ease of use and wearability, the 'blue jeans of the 21st century' (Fig.1. 8).[34] The issues of simplicity and authorship through fabric technology are extended in his *A-POC* line of clothing which exploits computerized tubular knitting (Fig.1. 9). The tube of fabric is

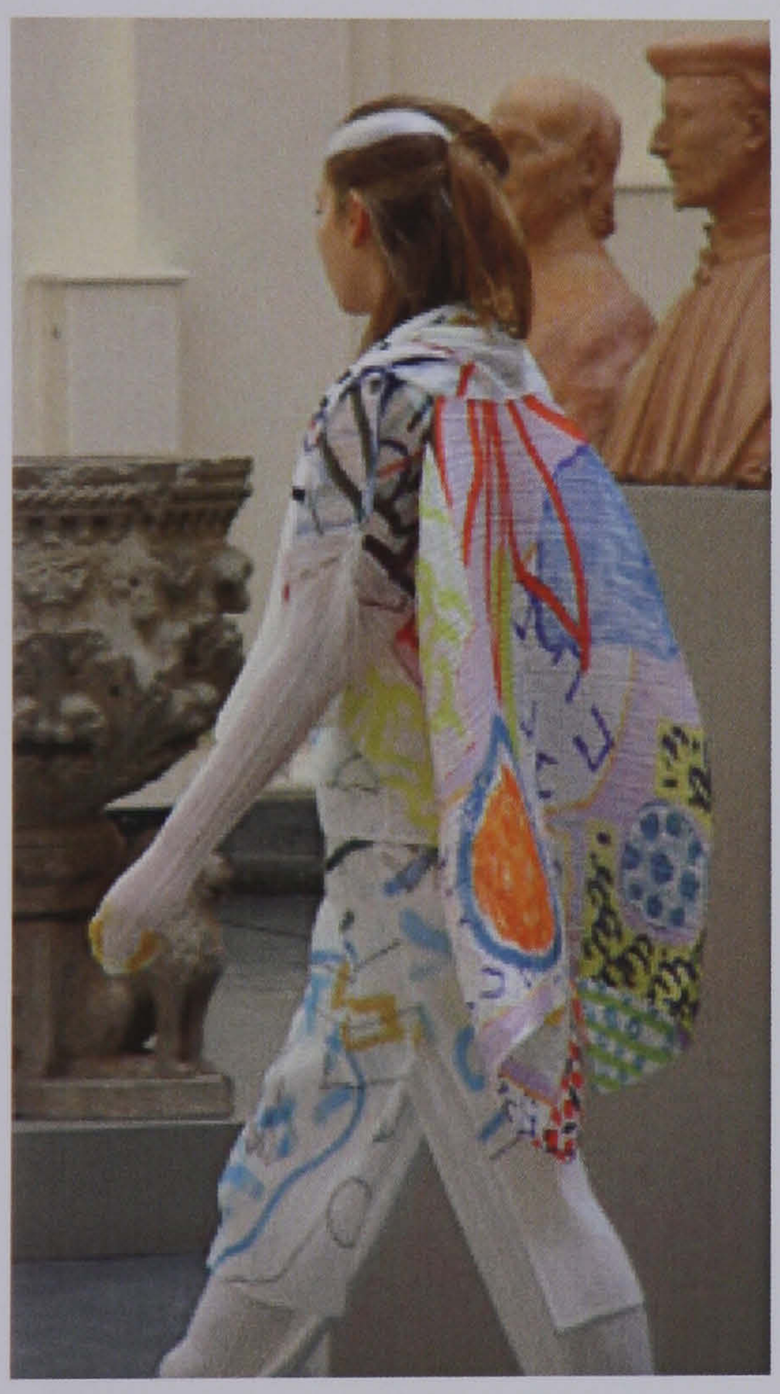

Fig.1. 8.
Issey Miyake, *Pleats Please* (2001). The pleated fabric expands to aid comfort, is easy to wash and easy to store.
Source:
http://www.vam.ac.uk/collections/fashion/fashion_motion/miyake/

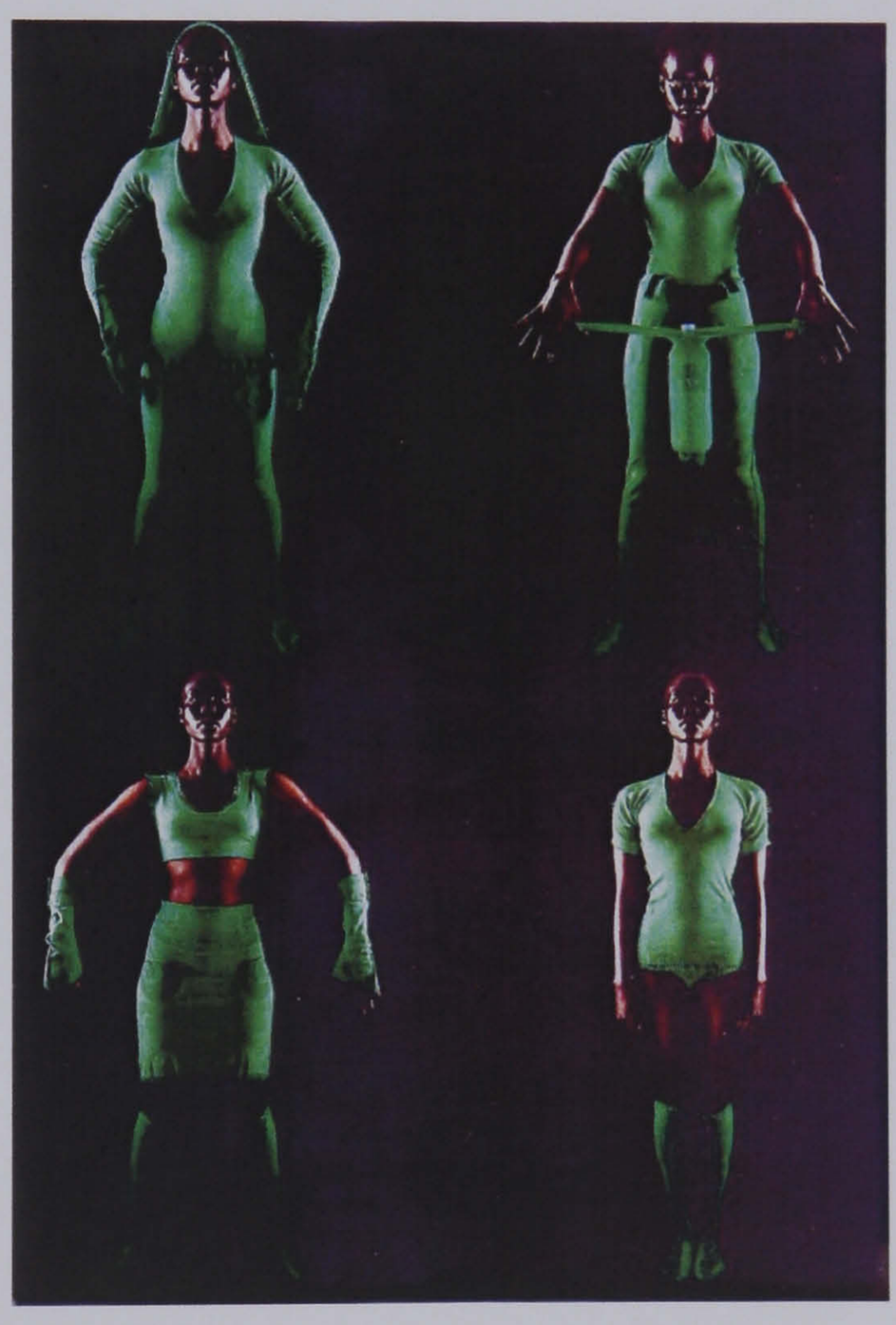

Fig.1. 9.
Issey Miyake, *Green Queen* (1999), A-POC (A Piece of Cloth) range, exploits computerized tubular knitting. The tube of fabric is embedded with the shapes of the garments, which can be selected and customized by the cut of the wearer.
Source: Issey Miyake, *APOC Making* (2001).

[34] Suzannah Frankel, *Visionaries: Interviews with Fashion Designers*. (London: V & A Publications, 2001), p 50.

embedded with the shapes of the garments, which can be selected and customized by the cut of the wearer.

Contemporary fashion has tentatively embraced fabric technology to improve garment performance and occasionally inform the design process but the look of the garments has not radically changed. Victor and Rolf's Autumn/Winter 2002 collection hinted at a way forward for fashion and technology by suggesting that garments could become an interface for digital information and images (Fig.1. 10). It featured garments that were the blue of the screens used in film making as a backdrop to special effects. A film about "diverse elements of life" was projected onto the models and a screen at the fashion show, alluding to a programmable fashion future where clothing is a blank canvas and technology provides a visualization of data.

Fig.1. 10.
Victor and Rolf, (Autumn/Winter 2002), shows high fashion engaging with ideas of technology and playing with the transience it might offer.
Source: http://www.firstview.com/

From an economic standpoint electronic and textile technology might present the European textile industry with an opportunity to 'weave' added value into garments and regenerate the home fashion industry.[35] Cheap garments already flood the domestic fashion industry and the end of the Multi Fibre Agreement in 2005 promises a further saturation of the European market by cheap foreign imports.[36]Smart textiles and electronic technology could provide new markets for the industry and new design processes for fashion design.

Perhaps the integration of technology could herald a return to an experimental way of working and a slowing down of the fashion cycle. Alber Elbaz has commented, 'Couture always used to be like a laboratory....It was the place they could work on ideas over time but fashion is not like that any more. It wants new, new, new and it wants it now.'[37] Technology may not be able to fully realize the 'now' but it could offer the 'new': new materials, new manufacturing processes and perhaps new cultures of clothing.

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[35] Xiaoming Tao, cites the Venture Development Corporation who estimated that smart fabrics and intelligent clothing will account for 720 million US dollars in 2008. Xiaoming Tao,'Introduction', in Wearable Electronics and Photonics, ed. by Xiaoming Tao (England; Woodhead Publishing Ltd in association with The Textile Institute, 2005), pp.1-12 (p.10).

[36] The MultiFibre Agreement (MFA) is a framework of bilateral agreements that established import quotas to countries whose domestic industries were facing extreme competition from imports. It has been in force since 1974 and was lifted in 2005. Kelly Dent and Mathew Tyne, *Unraveling the MultiFibre Agreement (MFA)* , Clean Clothes Campaign: Improving Working Conditions in the Global Garment Industry website <http://www.cleanclothes.org/legal/01-10_mfa.htm> [accessed: 29th September, 2005]

[37] Lisa Armstrong, 'Couture Why Does it Really Matter?', *The Times,* 28th January 2005, section T2.

Technology Enablers

Although there are few precedents in fashion for the integration of technology in clothing other fields such as wearable computing are investigating the functional possibilities of computing and electronics technologies on the body. Wearable computing demonstrates the potential of using technology to mediate between the body and the environment and provides tools for its implementation. The research of wearable computing (computational abilities on the body) began many years ago when Steve Mann joined Massachusetts Institute of Technology (MIT), and helped to form the Borg Lab (Fig.1. 11). There are now many wearable technology research departments around the world, looking to augment human capabilities or extend communication with the environment.[38]

Wearable Technology

In the last 25 years wearable technology in clothing has become prevalent in research, but for portable functionality rather than to explore new models of fashion styling. Collaboration between Levis and Philips electronics provided the first commercial foray into the merger of electronic technology and clothing for a fashion market. The ICD+ range was concerned with housing electronic communication and entertainment systems within jackets in a desirable and stylish manner (Fig.1. 12).[39] The jackets contained networked MP3 players, mobile phones and microphones so that a phone

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[38] For example, wearable computing groups at: MIT Media Lab, the University of Oregon, Carnegie Mellon, ETH Wearable Computing Laboratory in Zurich and at Bristol University.
[39] Notably the ICD+ range was designed by Massimo Osti of CP Company an Italian fashion label who include forward thinking pieces in their menswear fashion ranges. Although technology was not employed to enhance the look of the ICD+ range, aesthetics were a major bone of contention when considering how to 'sell' the technology to customers.

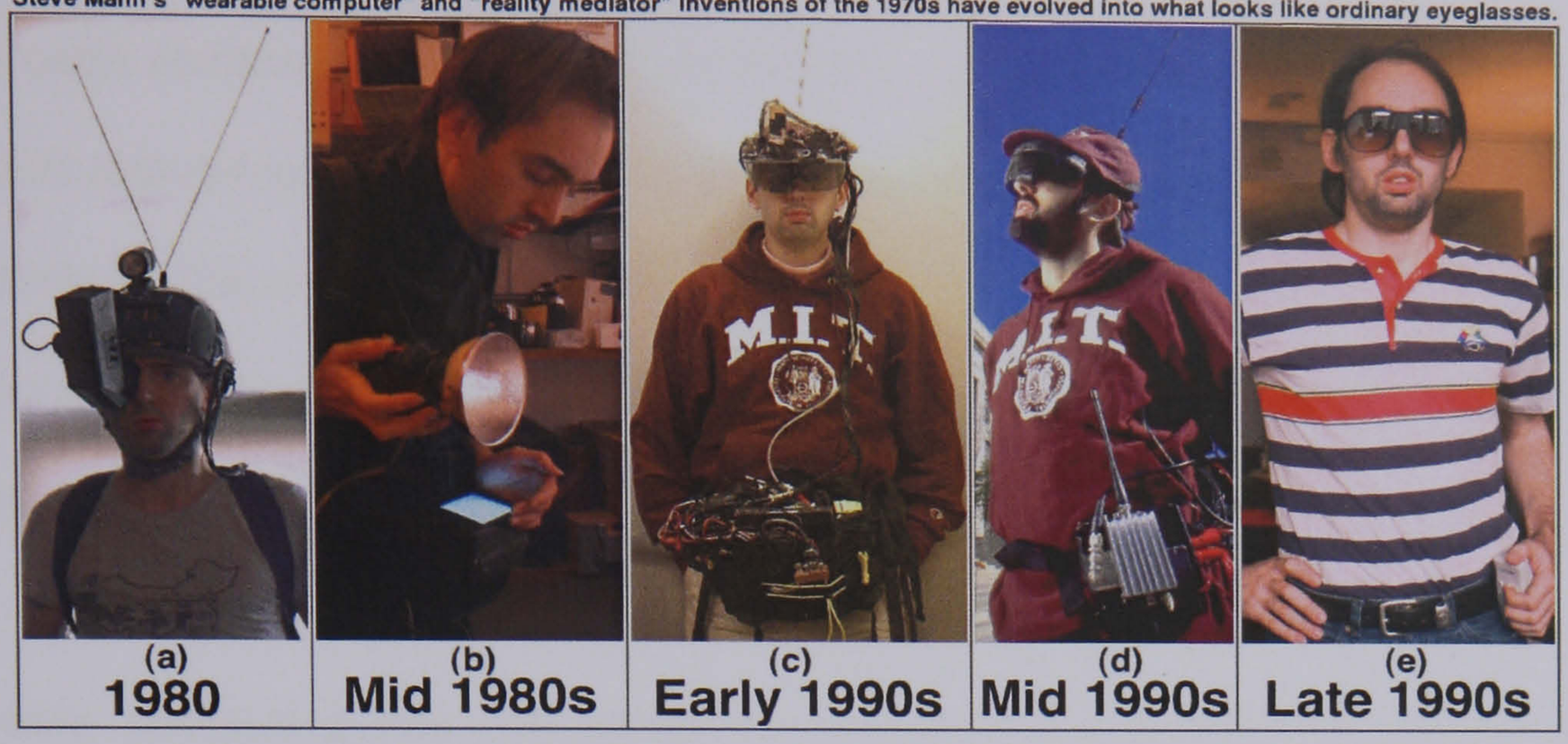

Fig.1. 11.
Steve Mann, *Wearable Computing* (from 1980's – 1990's). Steve Mann's personal imaging apparatus uses a camera and display, together with a powerful multimedia computer to create new opportunities for photography, videography, augmented reality, and `mediated reality'. The timeline shows the miniturisation of technology.
Source:http://www.wearcam.org/historical/

Fig.1. 12.
Philips-Levis's Industrial Clothing Division (ICD+) *Cagoon Jacket* (2001), is an example of electronic technology carried on the body. Although the electronic technology contained within the garment provided function rather than overt fashionability, it was one of the first forays into clothing and electronics by a fashion company.
Source: Andrew Boulton, *Supermodern Wardrobe*, (2002)

call would interrupt the wearer's music and enable the wearer to answer the call. The range used electronic devices and fashionable styling to lure buyers, suggesting that an inbuilt technology system was preferable to individual electronic modules carried on the body.[40] Since its introduction in 2001, a series of sportswear/electronics collaborations have resulted in mobile communication/ entertainment system, enhanced garments.[41]

Wearable computing has the ability to empower the wearer through control of electronic entertainment and communication systems or by performing remote health care or sports monitoring (Fig.1. 13). It can act as a conduit to the internet or as mobile information systems for the military and workers alike (Fig.1.14). The proximity to the body enables wearable computing to add convenient functionality to garments, and promises increased body to environment interaction.

Wearable Computing is not only functional but is being developed to be intelligent and context aware as Bradley Rhodes writes, 'By placing computing abilities in close proximity to the body, 'wearable computers have the potential to "see" as the user sees, "hear as the user hears, and experience the life of the user in a "first-person sense'.[42] Wearable computing has the ability to learn from the wearer and the environment and enable personal technologies to respond appropriately and intelligently. Thad Starner, a Professor of Wearable Computing at Georgia Tech

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[40] The range fitted into a larger techno-nomad fashion trend that included other companies such as Samsonite, CP Company and Vexed generation. See, Simon Boulton, *The Supermodern Wardrobe* (London: V & A, 2002), for a discussion of this area.
[41] Snowboarding brands Burton, Spyder and O' Neill have all produced garments with integrated fabric control panels that connect to I-pod's or mobile phones in the jackets.
[42] Bradley Rhodes, *Context –Aware Computing: Or, Why Context Needs Wearables and Wearables Need Context*, <http://www.media.mit.edu/wearbles/lizzy/context.html> [accessed 16th December, 2004)

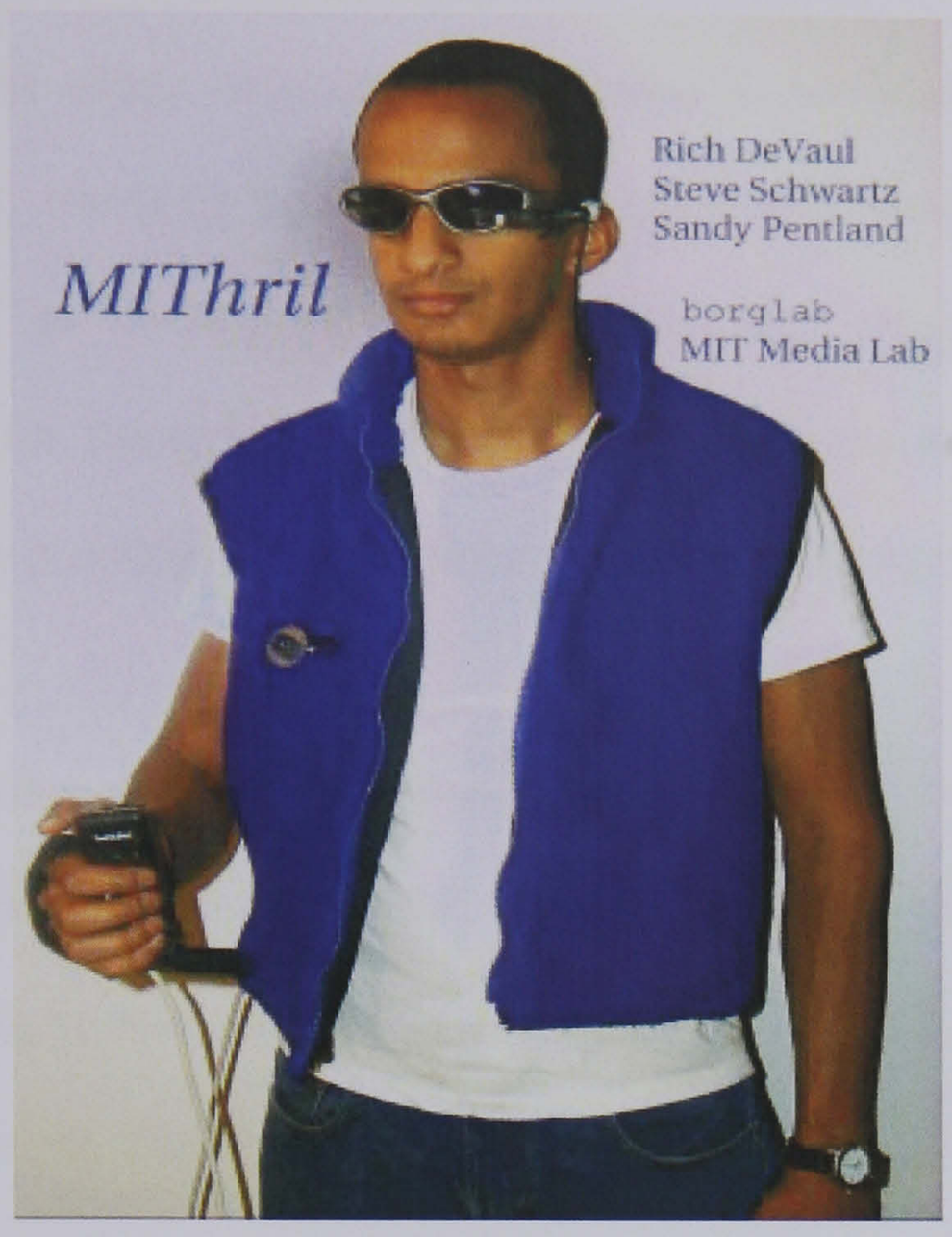

Fig.1. 13.
MIT, *MiThrill* (1001), provides a networked and integrated systems of sensors and computation capabilities on the body.
Source:
http://www.media.mit.edu/wearables/mithril/photos.html

Fig.1. 14
Xybernaut's *Mobile Assistant* (1999-2005) contains a digital camera, word processing and mobile accesss to the internet that can be used by workers in many industries including journalists.
Source:
http://www.xybernaut.com/industry.asp?categoryID=26&SecLevel=

(and an original founding member of the BorgLab at MIT) is researching context awareness to aid memory in everyday situations.[43] Although this could prove a useful tool, much of this and other research into wearable computing leaves the wearer looking like a cyborg, carrying boxes of electronics and wearing optical headsets. Wearable computing is developed by engineers and programmers rather than designers therefore the integration of technology is secondary to the research of technology to enhance everyday situations and increase functionality.

Within this field, there is a distinction between 'portable' (using the body and clothing to carry technology) and 'wearable' (integrating technology within the material of clothing).[44] It is this distinction that some areas of research are addressing, extending 'wearable' technology to mean a 'soft' compatible interface. This work uses the universality of clothes and their constant connection to the body to accommodate the growing ubiquitous and pervasive nature of technology.

> 'When thinking about context awareness or enhancing human performance awareness, e-textiles may just be the computing substrate needed for achieving it…allowing people to seamlessly move from one ambient to the other, with the clear advantage of being close to the human body…inconspicuously and without intrusion.'[45]

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[43] Thad Starner's memory aid uses either manual methods or a voice recognition system to input information into a wearable computer.Simon Garfinkel, *Wearing Computing for the Commons,* <http://www.technologyreview.com/articles/04/12/wo_simson120104.asp?p=0> [accessed 9th December 2004]
[44] Jamie Brasett, 'TechnoPlumage', from an unpublished paper, 2004.
[45] Diana Marculescu, and others, 'Electronic Textiles: A Platform for Pervasive Computing', *Proceedings of the IEEE,* 91 (2003), 1995-2018, (p.2015).

'E' or Computational Textiles

The first example of truly wearable technology is Georgia Tech's Wearable Motherboard project, later commercialised as the *Smart Shirt* by Sensatex Inc.[46] It was originally developed for the military to allow remote monitoring of soldiers in the field (Fig.1. 15). It is a woven t-shirt that utilizes fibre-optic sensors to transmit and receive information, visualizing the inner body as distant data upon a computer screen. Much progress has been made in the field of body monitoring for health care, enabling the constant remote monitoring of the body through interactive wearable technology (Fig.1. 16). The *Smart Shirt* suggests that computing and sensing capabilities in durable textile form can be compatible with the body and our care of clothing.

The *SmartShirt* led the way for 'e'-textiles: the exploration of computational textiles. The key components of electronic textiles are conductive fibres, threads, yarns, coatings and ink.[47] The embroidery of conductive threads and use of conductive fabrics were used to create one of the first 'e'-textiles projects at MIT Media Lab, developed by Rehmi Post, Maggie Orth and others.[48]

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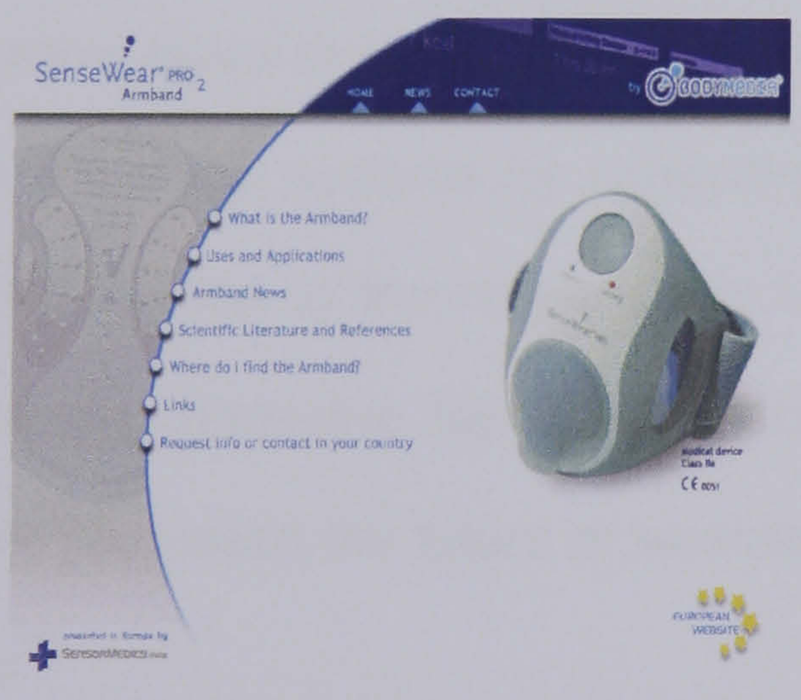
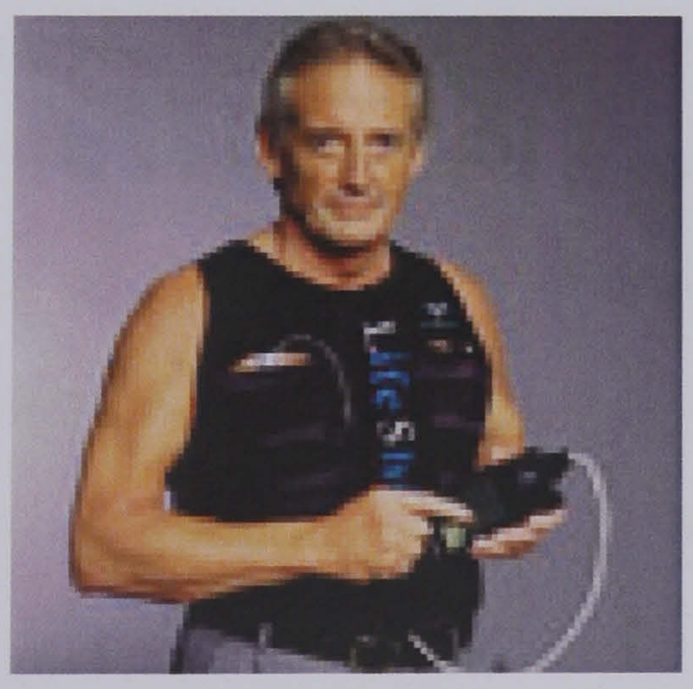
[46] See, Sensatex *Smartshirt*, <http://www.gtwm.gatech.edu/> [accessed 18 September 2005] and Sungmee Park and Sundaresan Jayaraman, 'Adaptive And R esponsive Structures (ARTS)', in *Smart Fibres, Fabrics And Clothing*, ed.by Xiaoming Tao (England: Woodhead Publishing Ltd in association with The Textile Institute, 2005), pp. 226-245.

[47] The most conductive textiles can be constructed from woven substrates that have metal wires such as brass, aluminium, or copper, interweaved within them. Printing, spattering, or impregnated textiles with carbon or metal powder can produce semi-conductive textiles. Conductive polymers, such as polypyrrole can be used to coat or impregnate conventional fibres, used alone to create fibres or blended with other polymers to engineer new conductive fibres. Conductive fibres and yarns can be also be spun or wrapped with non-conductive yarns, to weave into a fabric or streamlined into a thread, which is then embroidered onto fabric. See, Pu Xue and others, 'Electromechanical Properties of Conductive Fibres, Yarns and Fabrics', in *Wearable Electronics and Photonics*, ed.by Xiaoming Tao (England; Woodhead Publishing Ltd in association with The Textile Institute, 2005), pp.81-104 (p.81).

[48] E.R.Post and others, 'E-Embroidery: Design and Fabrication of Textile-based Computing', *IBM Systems Journal*, 39 (2000), 840-860.

Fig.1. 15.
Sensatex *Smartshirt* (2005) If a soldier is shot the Smart Shirt can locate their position and the extent of the injury. This technology has also been developed for remote health monitoring. http://www.gtwm.gatech.edu/
Source: http://www.sensatex.com/





Bodymedia Vivometrics

Fig.1. 16.
Bodymedia and Vivometrics are commercial examples of body monitoring systems which are hybrids of soft and hard components.
Source: http://www.vivometrics.com/site/system_howitworks.html and http://www.bodymedia.com/main.jsp

Fig.1. 17.
Philips, Business Suit (2000), used conductive threads to enable soft switching for computing and communication devices hidden inside the suit.
Source: Stefano Marzano, ed., *New Nomads* (2000).

Conductive textiles and threads are employed by Gorix as heating elements and Softswitch and Eleksen to produce embroidered pressure sensitive keypads.[49] Infineon use conductive tapes moulded onto other electronic components to create a series of removable electronic systems for controlling entertainment systems in snowboarding jackets.[50] In addition to the collaboration with Levis, Philips also produced garment concepts using conductive fabrics and soft switching, presented in *New Nomads*, a book which addressed the future of wearable computing in everyday social situations (Fig.1. 17).[51]

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[49] See, Gorix, <http://www.gorix.com/> [accessed 12 October 2004], Softswitch, <http://www.softswitch.co.uk/> [accessed 12 October 2004] and Eleksen, <http://www.eleksen.com/> [accessed 12 October 2004].
[50] See Infineon Technologies, <http://www.infineon.com/> [accessed 12 October 2004].
[51] Philips, *New Nomads*: *An Exploration of Wearable Electronics by Philips*, (Rotterdam: 010 Publishers, 2000).

For fashion applications, the more invisible the technology the better, so that technologically enhanced garments still look and feel like traditional garments. Elizabeth Smith commented on Hamish Morrow's Spring/Summer 2004 collection: 'The audience respond to the look of the garment, not the knowledge that it is at the forefront of technology.'[52] 'E'-textiles offer soft computing potential, a possible way forward to making technology acceptable to fashion. When 'e'-textiles are married to actuators (motion generating devices) or display technology new paradigms of fashion communication could emerge.

Shape And Texture Change

Responsive material technologies could dynamically extend fashion's capacity to communicate through colour, shape, pattern and texture, making these static design elements changeable and programmable. However, shape and texture change is the biggest challenge for material technology and the methods of achieving shape deformation are currently limited. One material successfully used by designers is Shape Memory Alloys (SMAs).[53] These are alloys (most commonly Nitinol, a mixture of nickel and titanium) that have the ability to memorize permanent or temporary shape. They switch between shapes when an electrical current or heat is applied.[54] A technology that is still being developed is Electroactive Polymers (EAPs), polymers that can move upon the application of an electric current. EAPs are used to produce

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[52] Elizabeth Smith, 'A Fashionable Future', *Selvedge*, May/June 2004, p.28.

[53] Grado Zero Espace, a research and development spin-off of the company Corpo Nove, have woven Shape Memory Alloys into a temperature sensitive fabric to create the *Oricalco* shirt. The *Oricalco* shirt bunches and wrinkles as a normal shirt when worn but relaxes and uncreases when exposed to a hot air source such as a hair drier. See Grado Zero Espace, <http://www.gzespace.com/> [accessed 30 January 2006]. Other examples of Shape Memory Alloys used to create shape-change in garments and jewellery can be seen in the *Shape Memory Dress* of Hussein Chalayan and the *Aliform* neckpiece of Sompit Moi Fusakul (see Practice Review).

[54] See, Memory Metals, <http://www.memorymetals.co.uk/> [accessed 20 December 2003]

actuators but could be used in the future to create controllable surface textures for "active" military camouflage or haptic displays.[55] Although this technique is still in development, EAPs could be manufactured in fibre form in the future to create moving surfaces and ultimately shape-changing materials.

Colour Change

In contrast to shape change the possibilities for colour change are more varied. The majority of colour-change technologies available to designers use light in various forms. LEDs, fibre optics, electroluminescence (EL), and light emitting polymers were all originally intended for other applications.[56] For example, the use of EL, a phosphor based colour change technology that is used for advertising displays.[57] EL has several disadvantages for use in clothing: it requires an inverter to alternate the electrical current, it needs large amounts of power and can be hazardous to the body so must be covered by plastic casing. Despite these drawbacks, EL has been used in garments to create reactive and programmable displays. [58]

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[55] SRI International, a non-profit research laboratory in California have found that dielectric elastomer polymers can be coated onto thin films with compliant electrodes to create a moving surface. See, SRI International, <http://www.sri.com/> [accessed 15 June 2004]

[56] LEDs are small powerful bulbs that are used in everyday products such as on/off lights in electrical products. Barbara Layne uses LEDs to create controllable lighting displays. See, Barbara Layne, <http://www.hexagram.org/hexengine/projects.php?command=ViewProject&project_id=90&lang=en> [accessed 11 December 2004].

[57] EL is phosphor sandwiched between two electrodes. When electricity is applied, the energy excites the phosphor causing it to glow. EL can be obtained in various forms. Companies such as Elumin8, <http://www.elumin8.com> [accessed 18 February 2004] manufacture EL panels, Surelight, <http://www.surelight.com/> [accessed 1 March 2004] sell EL wire and Crosslink Polymer Research, <http://www.crosslinkresearch.com/> [accessed 14 June 2003] develop and licence EL as a printable polymer.

[58] It has been used in panel form by Megan Lee Galbraith in *Elroy*, as wire in Cute Circuit's *Kinetic Dress* and printed onto a jacket by Elise Dee Co for her Puddlejumper concept (see Practice Review). Also, The Visson company have used EL coated conductive fibres in a woven structure to create thin and flexible displays. When the structure is electrically stimulated, it emits light at the point where the rows and columns of conductive fibres meet. See, Visson, <http://www.visson.net/> [accessed 15 June 2004].

Designers and industry have also used fibre optics to create changeable displays. Fibre optic cable is used to channel LED light. The light travels to the end of the cable which then becomes illuminated. If the surface of the cable is removed through abrasion techniques, light can be dispersed along the length of the cable to create a light emitting fibre (Fig.1.18). France Telecom has developed programmable woven fibre optic displays that can show moving text or simple images (Fig.1.19). The project shows that programmable/ downloadable displays could lead to the personalization of electronic clothing. The wearer could create her or his own display designs, resulting in choice and creativity.

A technology that could provide other possibilities for customization are chromic inks which respond to different stimuli: thermochromic inks respond to heat, photochromic to UV light, hydrochromic to water and piezochromic to pressure. They can be engineered to react to different thresholds providing colour change possibilities. Thermochromic inks can be screen printed in the traditional manner or used as dyestuff with the addition of a chemical agent. They are used mainly by the advertising industry to create promotional products but are popular with textile and fashion designers as they can be applied to fabrics using established, low tech textile printing and dying processes.[59] The popularity of thermochromic inks show that material technology is embraced by fashion and textiles designers when it can be experimented with using traditional processes or be treated as a traditional fabric.

Another possibility for the future is the development of electrochromic polymers which change colour when an electrical field is applied. At present the polymers are used as

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[59] MaggieOrth in her work with International Fashion Machines has used thermochromic dyes in conjunction with conductive fibre to produce *Electronic Plaid* (see Practice Review).

Fig.1. 18.
Luminex. An abrasion technique was used to create a woven light emitting fabric for clothing and accessories.
Source: http://www.time.com/time/2003/inventions/invluminex.html

Fig.1. 19.
France Telecom, C*reateWear* .Programs can also be downloaded from the internet to program the display.
Source: http://www.studio-creatif.com/Vet/Vet03CreateWear01Fr.htm

a film in architecture and the automobile industry, to provide controllable window treatments.[60] They have also been developed as colour change false nails.[61] Professor Richard Gregory at Old Dominion University in Virginia, is applying this technology to the development of 'chameleon fibres': conductive fibres coated with an electrochromic polymer.[62] This development could provide a yarn-like colour change technology that could be woven or knitted as cloth rather than be wired into a garment.

Black and white colour change could be materialised through 'E'-paper which has been hyped as the answer to printing the daily paper. It utilises 'e'-ink, which is microencapsulated black and white particles suspended in a clear fluid.[63]. The ink can be printed onto a variety of surfaces such as paper, plastic and fabric providing another potential route to realising a programmable changing fabric in the future. This technology has been under development for many years at Gyricon (a subsidiary of Xerox) and E ink (Fig.1. 20). [64]

These examples of material technology show that programmable colour change materials are becoming a reality for the future but are still not viable for fashion. The ultimate aim would be to produce a dynamic colour change fabric or programmable

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[60] An electrochromic polymer film is sandwiched between two panes of glass. The polymer in the glass is able to switch from clear to coloured when an electrical current is applied.
[61] Materials scientists at Cidetec have used the films to create an electrochromic nail, which can be programmed to create different images on its surface. See, Cidetec, <http://www.cidetec.es/> [accessed 13 November 2003] and David Adam , 'What's an Electrochromic False Nail?', The Guardian, 13 November 2003.
[62] See this brief paper for an explanation of his work with chameleon fibres, <http://www.ntcresearch.org/pdf-rpts/AnRp04/M01-CL07-A4.pdf> [accessed 20th November 2004].
[63] The particles are negatively and positively charged so that a corresponding current can flip the particles to reveal either a black or white surface. Printing the ink onto a substrate and laminating it with a layer of circuitry creates a changeable and flexible pixel display.

Fig.1. 20.
Polymer Vision, *Electronic Paper* (2005). Philips collaborated with E ink to produce a flexible electronic display and in 2004 set up Polymer Vision, a company to commercialise the product.
Source: http://www.polymervision.com/Technology/Index.html

display system that could be incorporated invisibly into clothing and could be sewn and manufactured using traditional methods. It would also need to be durable enough to be washed and worn in the same way as any other garment. At present this is not possible but if realised in the future, could provide new levels of garment customisation and longevity, which could address notions of change, ambivalence and identity in fashion. In this way a fashion and technology merger might offer a more personal expression of self and enhance our emotional connection to clothing.

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[64] See, Gyricon <http://www.gyricon.com/> [accessed 27 August 2004] and Philips and E-ink's company Polymer Vision, <http://www.polymervision.com/> [accessed 14 November 2004].

Emotional Design

Context - The Age Of Emotion?

The concept of "emotional design" and of emotional interaction with technology has developed in the fields of product and industrial design and human-computer interaction (HCI).[65] It is a field that might provide useful paradigms for the marriage of technology in clothing by showing how design techniques could make technology in garments emotional and acceptable. The term 'emotional design' is perhaps a statement of the obvious; as research into emotions has shown that all experiences are emotional whether they work at an unconscious or conscious level.[66] Emotional design is about finding ways to make the 'grades' of emotional response stronger by understanding what elements in design can provide 'emotional clues'.[67] It could be said that the aim of emotional design is to make us respond favourably to a product so that we will choose it, enjoy it and keep it.[68] Art Swanson makes the point that emotion can not be designed as all emotions are experienced subjectively but ' we can impact

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[65] There are publications that analyse the nature of emotional design, such as Donald. A. Norman, *Emotional Design: Why We Love (or Hate) Everyday Things* (New York: Basic Books, 2004) and organisations that specifically address these concerns, such as the Design and Emotion society. See Design and Emotion website, <http://www.designandemotion.org/> [accessed 12 April 2004].

[66] However, as Antonio Damsio points out, an emotional distinction can be made between objects, which are based on 'grades' of emotion i.e. whether an emotional reaction to an event or object is weak or strong. See Antonio Damasio, *Looking for Spinoza: Joy, Sorrow and the Feeling Brain*, (London: Heinemann, 2003), p.56. and Joseph Le Doux, *The Emotional Brain: The Mysterious Underpinnings of Emotional Life*, (London: Phoenix, 1999), p.69.
It has also been shown that our emotional reaction is most influenced when we are not aware that we are being influenced, i.e. we can be persuaded by subliminal messages or emotional clues. See, Joseph LeDoux, pp.57-59.

[67] After survival, emotions are generally used to effect change in others. As Rita Carter states, 'their purpose is largely to bring about a corresponding emotional change in other people, which causes others to behave in a way that is beneficial to us'. See, Rita Carter, *Mapping the Mind,* (London: Phoenix, 2004), p.133

[68] Emotions play a very important part in rational decision making, without emotions we find it hard to make a choice so it makes commercial sense for products to help us choose by eliciting emotions. See, Antonio Damsio p.140

emotional response through the products physical aspects', and he notes that this requires attention to 'all interactions with the product'. [69]

Emotion is a prevalent theme in contemporary research. More human orientated solutions are being sought through research fields such as affective computing which is endeavouring to give computers the ability to feel, recognise and react to emotion.[70] Emotional music cues are being researched to enhance the emotive quality of computer-generated music.[71] Sensory (Kansei) engineering or 'emotional usability' seeks to relate human sensory perception and physiological response to perceptual design features.[72] There is also neuroscience research into the origins of emotion in the brain[73] and debate about biotechnology's ability to control them.[74] Why such interest in emotions? Researchers in many fields are arguing that technology needs to become personalised and human-centric, adapting to the user as the user adapts to the technology. They propose that user interaction can be made meaningful by looking

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[69] Art Swanson and Ross Teague, *Emotion and Design F.A.O: Building a Product That Works and Connects With Users,* (2004) <http://www.localtechwire.com/printstory.cfm?u=9394> [accessed 25 August 2005].
[70] Rosalind Picard, *Affective Computing* (Cambridge, Massachusetts: The MIT Press, 1997).
[71] Bresin, R., and A. Friberg, 'Emotional Coloring of Computer-Controlled Music Performances', *Computer Music Journal* ,4 (2000), 44-63.
[72] 'Kansei is a Japanese word meaning "emotion", in the sense of acquired sensibility towards art and music as a whole.' See, Marcelo M. Wanderley,'*Internal Report – Kansei the Technology of Emotion Workshop, Genoa, Italy, January 1998*', <http://recherche.ircam.fr/equipes/analyse-synthese/wanderle/Gestes/Externe/relkansei.pdf> [accessed 3 February 2005]. Sensory (Kansei) engineering understands that designing functional and usable products negates the emotional experience a user has with a product. It recognizes that an emotional response to a product is a total sensory experience encompassing the look, touch, sound, smell and even taste of a product in context with its use. Kansei engineering methods vary; for example, some methods use example products that exhibit contrasting characteristics to gage and evaluate user response and other methods use the measurement of brain waves or body physiology to understand the response of the user. For examples of methods, see Ergosoft Laboratories <http://www.ergolabs.com/kansei_engineering.htm> [accessed 20 January 2006] and Roger L. Barker, Moon W. Suh and others,'Sensory (Kansei) Engineering of Aesthetics in Textile Fabrics', *National Textile Center Research Briefs*, (2000), 37.
[73] Joseph LeDoux, *The Emotional Brain: The Mysterious Underpinnings of Emotional Life*, (London: Phoenix, 1999).

to our social and cultural world. Cass, Goulden and Kozlov write,

> These needs are not functional or physiological but psychological and cultural. They include the need to represent roots and heritage, to create a sense of belonging and connectedness and to demonstrate personal identity and achievement.[75]

Fashion can create a sense of belonging and of personal identity as it functions as an interface between the individual and society. It is a visual display of choice and a powerful cultural communicator of self. It appears that fashion already addresses many of the same emotional concerns that researchers and technologists are interested in. However an emotional design context might reveal new ways for fashion to think about technology mediated interactions with the wearer.

Pieter Desmet

In the field of emotional design there are those seek to understand and classify emotional response to products and those who use technology or design to enhance our everyday interactions and relationships with objects, people and environments. Pieter Desmet is an industrial designer who sits between the two camps and who has investigated user's emotional responses to everyday objects to help designers create more emotional products.[76] He acknowledges that emotions are personal, contextual

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[74] Francis Fukuyama,'They May Live for Ever, but Will They Still Be Human? How Science is Destroying Us', *The Guardian*, 13 May 2002, section G2, pp. 2-5.
[75] John Cass, Lorna Goulden and Slava Kozlov, 'Intimate Media', in *The New Everyday: Views on Ambient Intelligence*, ed. by Emile Aarts and Stefano Marzano (Rotterdam: 010 Publishers, 2003), pp. 218-223.
[76] He used a database of photos and emotional responses to construct a Product Emotion Measurement instrument or PrEmo to measure emotional response to new and existing designs. His [product & emotion] navigator support designers attempting to manipulate the emotional impact of their designs. His tools offer distinctions rather than design rules,i.e. a tool to familiarise designers with the model of product emotions, key variables and how they come

and temporal. The implication for designers is that, 'emotions can only be understood in relation to the person experiencing them.'[77] Therefore an almost scientific approach to designing emotional products seems unhelpful especially to fashion, our most intimate and personal 'product'.

Pieter Desmet's thesis that the measurement of emotional response is problematic (although partially quantifiable) is a useful corrective to The Emotional Wardrobe. Emotional response to the practice could not be measured in a specified form but it could be understood through personal interaction with the audience. I was less interested in his classification of emotions in response to objects and more in his suggestion that products could elicit mixed and paradoxical emotions. Desmet comments,

> It may be interesting for designers to investigate the possibilities of designing paradoxical emotions because this may result in products that are unique, innovative and rich, and more challenging or appealing than those that elicit only pleasant emotions.'[78]

Desmet has shown through his research that a mixture of emotions are elicited at any one time and Donald Norman states that conflicting emotions can be, 'combined to form an enduring, if uncomfortable relationship [to objects].[79] The use of paradoxical emotions in design could enhance these conflicts building on the natural order of things. If products or garments only provide positive emotions, perhaps we would

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together to create patterns of eliciting conditions. See, Pieter Desmet, *Designing Emotions*, (Delft: Delft University of Technology, 2002), p.163.

[77] Pieter Desmet, p124

[78] Pieter Desmet, p.191.

[79] Don Norman, p.157.
In evolutionary terms it is beneficial to have both happy and sad emotions. Positive emotions give us a resolution to negative emotions and negative emotions stimulate the pursuit of happiness. Happiness is designed to help us survive but it is also designed to fade, leaving us hungry for more. See, Robert Wright, 'Dancing to Evolution's Tune', *Time,* 7 February 2005, Viewpoint, p.51 and Michael D. Lemonick,'The Biology of Joy', *Time,* 7 February 2005, p.555

become bored, complacent and not consume?[80] He also makes the distinction between products that express emotions and products that elicit emotions, his research focuses on the latter but what if a product or an item of clothing expressed emotions as well as trying to elicit them?[81] The expression and elicitation of paradoxical or darker emotions could provide a more potent emotional experience for the wearer or the viewer.

Donald Norman

Norman is a professor of computing science and psychology with an interest in understanding and enhancing our relationships with objects via human-centred products. His work provides another approach to emotional design that could prove influential to fashion and technology. He proposes three design categories for emotional products: visceral, behavioural and reflective. Visceral design is about the look, feel and sound of an object, behavioural design focuses on function and usability and reflective design is about meaning and how product messages inform our self-image.[82]

His ideas can be applied to fashion as fashion is already visceral and reflective, although often usability is ignored and sometimes challenged in favour of the communication of ideas. When thinking to the future of technological enhancement in fashion, function and usability might become a more pertinent problem as technology can be complicated and user 'unfriendly'. Norman says that simple physical controls are important as they give a better sense of control to the user. Design can help by giving clues of how to use products, which in this case would be the vocabulary of

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[80] Negative emotions are potent and rapid, we are predisposed to pay attention to and remember negative emotions, as they carry consequences. See, Reeves and Nass, p119-120.
[81] Products or computer interfaces that express human attributes are known as anthropomorphic.

fashion. [83] The physicality of garments could be used, so that a button or zip could become a switch or pushing up sleeves could dim the garment display. Interaction with technology in garments should be intuitive and soft and not resort to hard buttons and boxes.

Reflective design relies on memories that are formed about experiences, people and objects as well as evaluations about the self. Norman emphasizes that it is not the object itself that is important in creating emotional memories but the meanings and feelings that the object represents. In this way, reflection could be seen as a cyclical narrative between the user, object, meanings, memory. Fashion already uses aesthetic or visceral design to stimulate memory and narrative through the ideas of the designer and their social, cultural and historical influences but how could technology augment these elements?

Using technology in fashion to enhance Norman's three emotion categories and employing Desmet's paradoxical emotions new paradigms of fashion might emerge. These elements together might also create greater emotional attachment to technology. The following designers illustrate these theories through practice.

Dunne And Raby

The industrial designers Anthony Dunne and Fiona Raby adopt a critical approach to the design of electronic objects that is opposed to the 'ultra-conservative' constraints that the industrial design industry mediates. [84] Dunne proposes products that include

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[82] Donald Norman, pp.63-98
[83]Norman, D. A., *The Psychology Of Everyday Things* (New York: Basic Books, Inc.,1988)
[84] Anthony Dunne, *Hertzian Tales*. (London: RCA CRD Research, 1999).

the user in poetic experiences through the use of electronic objects; his aim is to reveal thought-provoking narratives in everyday use. In their work, Dunne and Raby recognize that the user may have other darker desires and needs that are not catered for by mass-produced objects (Fig.1. 21). They term this expansion of psychological experience *Design Noir*. In their designs the electronic object engages the viewer or user with the invisible world of the electromagnetic environment to make '*Visible the Invisible*' and to provoke reflection about its unseen character.[85] However, it is not the visual character of the object that provides the narrative but the experience that the object mediates: the 'Aesthetics of Use'.[86] The aesthetics of the object become secondary and unobtrusive; attention is deflected from the look of the product in order to provoke questions about its subversive function. The *Nipple Chair* from the Placebo Project, discussed in *Design Noir*, illustrates this philosophy through its playful 'visualisation' of electromagnetism and its ability to change behaviour or emotional feeling through the experience of using the product (Fig.1. 22).[87]

Dunne and Raby's concerns show an alternative approach to the traditional design of electronic objects. The emphasis has shift from product aesthetics and utilitarian function to the poetic experience that the product can mediate. This approach suggests a new way to design fashion, focusing not only on the look or concept but also on the experience of wearing. The user could be encouraged to take part in the narrative

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A.Dunne and F.Raby, *Design Noir: The Secret Life of Electronic Objects.*(Basel: Birkhauser, 2001). From an interview with the designer, Anthony Dunne. London, 3 March, 2003.

[85] 'Making Visible the Invisible' is a sub-title in Chapter 6 of Hertzian tales and is used to suggest work that exposes the electromagnetic environment.

[86] The term 'Aesthetics of Use' is used by Anthony Dunne to define an object that creates reflection through use rather than by visual means. See Dunne, *Hertzian Tales*. 'Para-Functionality:The Aesthetics of Use,' pp. 42-57.

[87] Items from the Placebo Project were given to members of the public for a period of use within their own homes, as 'social probes', to test the success of the furniture. The designs allowed the public to take part in an experience through the product and its psychological impact. Most of the users enjoyed the interaction and wanted to keep the products. This suggests that more thoughtful narrative products could have a place in our everyday life.

instead of being a passive consumer and the designer become 'a provider of new behavioural opportunities'.[88]

Ted Noten

In common with Dunne and Raby, Ted Noten's jewellery investigates non-traditional 'dark' subjects the psychological dimension in his work becomes an added experience of wearing or viewing. Although his pieces can be worn it is the stories that they tell that allow them to transcend pure ornamental use, as in *Princess* (Fig. 1. 23), a contradictory mixture of death and beauty. Contemplation is further encouraged by the involvement of the wearer in the construction of meaning, illustrated in his *Chew Your Own Brooch Project* (1995). [89] The wearer is required to chew gum into a desired shape and send it back to the designer who uses the gum to produce a mould, which is transformed into a silver or gold artefact. Personal identity is transferred in the choice of shape modelled by the participant and the imprint of the teeth and the DNA contained in the saliva.

Boudicca

The fashion designers Boudicca have also used ideas about dark emotions, garment narratives and garment/body interactions in their work.[90] Themes such as emotional isolation and death pervade their work; their garments are not about aesthetic

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[88] See Dunne, *Hertzian Tales*, p 58.
[89] See, L.L. Leslie, 'Of Mice and Men', *Frieze*, May 2002, pp.46-47 and G. Staal, *Ted Noten* (Amsterdam: Galerie Louise Smith, 2000).
[90] Also, much of high fashion in the 1990s dealt with dark motives such as, the brutalized body and decadence and decay, see Caroline Evans, *Fashion at the Edge: Spectacle, Modernity and Deathliness* (New Haven: Yale University Press, 2003) and Rebecca Arnold, *Fashion, Desire and Anxiety: Image and Morality in the 20th Century* (London: I.B.Taurus, 2001

Fig.1. 21.,
Anthony Dunne's, *Thief of Affections* (1999), the 'protagonist' is an, anti-hero, a perverse character that steals the radiation of a pacemakers through the electronic object. The user is no longer stereotypical but has different needs and pleasures.
Source: Anthony Dunne, *Hertian Tales* (1999)

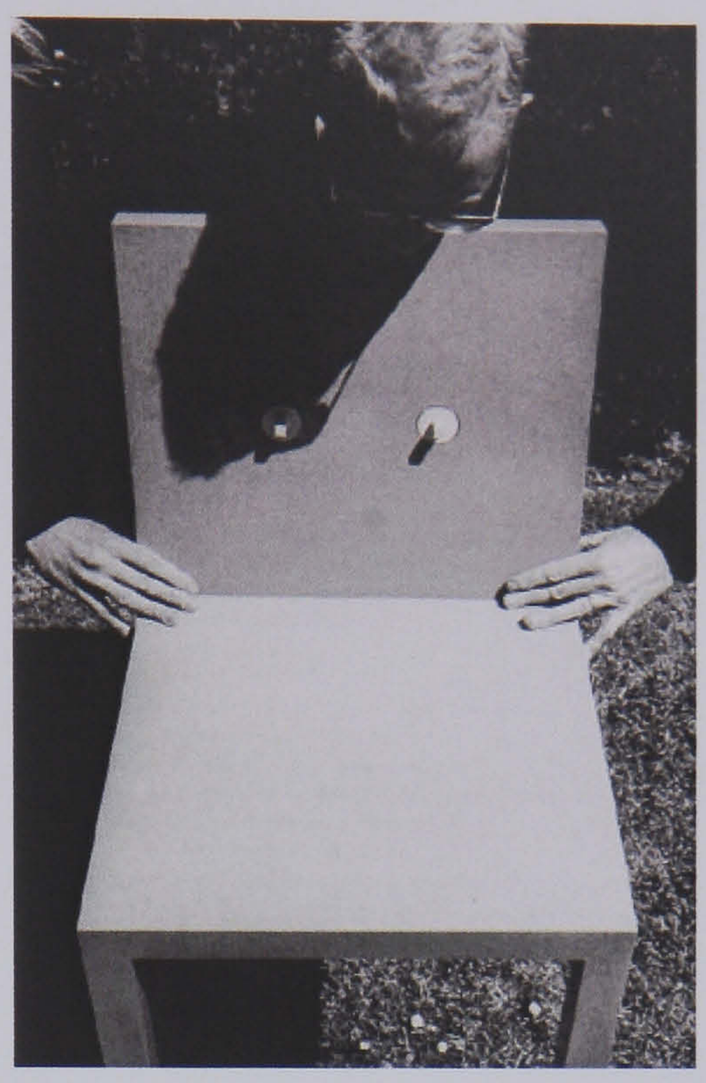

Fig.1. 22.
Anthony Dunne & Fiona Raby, *Nipple Chair* (2001), senses electromagnetic fields and reacts accordingly, buzzing and vibrating through the nipples in its seat back alerting the sitter to the presence of electromagnetic waves travelling through their torso. This action could motivate the sitter to stay in the same position or move to another area that is more conducive to their mood.
Source: Anthony Dunne & Fiona Raby, *Design Noir* (2001)

Fig.1. 23.
Ted Noten, *Princess* (1995). A dead mouse is adorned with a pearl necklace and shrouded in Perspex to form a necklace juxtaposing precious and found materials. It is strangely beautiful and compelling, prompting meditation about death and mortality, life and value: 'noir' subjects for 'ornamental' jewellery.
Source: *Frieze*, May (2002)

Fig.1. 24.
Boudicca, (Autumn/Winter 2000). The shirt 'explores emotional restraint'.
Source: The Daily Telegraph, July (2000)

decoration but ideas that comment on the world and the human condition. Their clothes are provocative and require a certain amount of intellectual involvement to fully appreciate their vision. Garments act as a narrative, encouraging the wearer to engage with the subject matter to varying degrees. Their Spring Summer '99' collection was inspired by the nation's response to the death of The Princess of Wales. It commented on a quest for fame and immortality that accompanies the modern culture of celebrity. A notebook accompanied each garment to encourage the wearer to document the life of garment, when and where it was worn. In this way the garment and the notebook became the mediator of an interactive experience that provoked reflection on life and death. Their Autumn Winter '99/ 00' collection, took the reclusive lifestyle of Howard Hughes as its theme. It includes *Embrace Me*, a jacket that encourages others to touch or embrace the wearer through the use of tactile fabric and hidden pockets, and a *Solitary Dress* that utilized slits at the sides to allow the wearer to hug herself (Fig.1. 24). [91]

Boudicca treat these quirky ideas with subtle, solemn reverence and impeccable tailoring. They do not hide or over emphasize the intent through elaborate decoration. Their dark subject matter could, like Dunne and Raby's, be termed *Design Noir* for their garments carry a touch of estrangement, a characteristic that Anthony Dunne believes is necessary to provoke reflection. The garments are both recognizable and slightly alien, inhabiting the space between reality and fiction.

The work of Dunne and Raby, Ted Noten and Boudicca all suggest that design can provide or illustrate dark psychological experiences, be used to create user-focused

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[91] Boudicca (1998) *Sleaze Nation*, 2(6) June 1998, pp. 20-21
Stungo, N., 'Boudicca', *Blueprint,* October,1998.p.

narratives and interactions and can provide a democracy of design enabling the construction of non-generic definitions of identity.

Anthropomorphism

Another form of emotional design that uses narrative devices to create emotional connection is anthropomorphism: giving products and interfaces human characteristics. This is an approach that relies on human-like narratives between product and user to enhance interactions with technology and design. It exploits our tendency to automatically respond to anthropomorphic objects and interactive technology as if we are exchanging emotional communication with each other. [92] From a fashion point of view we imbue garments with personality while we are wearing them but we do not give the garment itself a personality or human characteristics. Designing human type attributes and responses into garments could help elicit emotions from the wearer/ viewer and create emotional connection to the technology. The work of Gitta Gschwendtner and Philips Electronics can be contrasted to show two different approaches, one with high technology, one without.

Gschwendtner's work is about story telling, she describes her work as, 'Active objects frozen mid-sentence,' they are also, 'attention seeking'.[93] The narrative and suggested anthropomorphism is very evident in her *Strangled Lights* (see Case studies), which are literally hung from the ceiling, her *Between the Lines* table that appears to be eating magazines and her *Up the Wall Lamp*, which seems to be climbing the wall in a slug-like motion (Fig.1. 25.). These designs are inanimate but the power of suggestion

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[92] The concept of people responding to technology as if it is human has been extensively researched by Reeves and Nass, see Byron Reeves & Clifford Nass, *The Media Equation*: *How People Treat Computers, Television, and New Media Like Real People and Places*, (United States of America: CSLI Publications and Cambridge University Press, 1998).

gives them emotional life. In contrast, Philip's *Smart Companion* is all-singing-and-dancing technology, designed to interact in a human way with its owners (Fig.1. 26.)[94] However, it lacks tactile material quality, tactile and beautiful fabrics and natural materials. Fashion has a big advantage over new technology in its ability to manipulate traditional fabrics, which already have reflective and visceral characteristics. Fashion could utilize this fact when integrating technology to enhance the way the garment behaves and interacts with us. This has considerable potential in the context of active aesthetics facilitated by technology. A garment could become more than a garment: a personality that stimulates and expresses all the contradictory emotions that we experience. Creating dynamic garment design using material technology opens up possibilities of interaction with garments and others that have been unachievable before now:

> When something gives pleasure, when it becomes part of our lives, and when the way we interact with it helps define our place in the world, then we have love. Design is part of this equation but personal interaction is the key.[95]

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[93] Lesley Jackson, ' Gitta Gschwendtner', *Icon*, 15 September 2004, pp 72-76.
[94] Philips Smart Companion, <http://www.research.philips.com/password/archive/23/downloads/pw23_personaltouch_14.pdf > [accessed 20 August 2005].
[95] Norman, p.227.

Fig.1. 25.
Gitta Gschwendtner, *Between the Lines* and *Up the Wall* (2002), use traditional materials and anthropomorphic design clues to suggest inanimate objects that are 'alive'.
Source: *Icon*, September (2004) and Jane Pavitt, Brilliant Light And Lighting (2004)

Fig.1. 26.
Philips, *Smart Companion* (2005), can speak, understand speech and can recognize face and gestures to interact intuitively with its owners.
Source:
http://www.research.philips.com/password/archive/23/pw23_smartcompanion.html

Mob Comms

Norman moves the focus of interaction to personalised human/human interaction in his discussion of mobile communications. Mobile phone technology is one of our most pervasive and accepted forms of technology and is primarily concerned with social interaction. Mobile communications (mob comms) have many similarities to fashion and could be seen as a precedent for how people might use fashion as a communication tool in the future.

Phone technology offers many levels of communication: verbal (the call), written (text messages), visual (photography and video), entertainment (games and music download capacity) and information gathering and sharing by connection to the internet.[96] Phones are "emotional" that is, they are visceral, behavioural and reflective.[97] However, they can have both positive and negative effects: they can both extend and disrupt communication by interfering in face-to-face communications. As Norman observes, 'by continually being in communication with friends across a lifetime, across the world, we risk the paradox of enhancing shallow interactions at the expense

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[96] John Boyd, 'The Only Gadget You'll Ever Need', *New Scientist* , 5 March 2005, p.28.

[97] They are visceral as the look and feel of mob comms are becoming more important with possibilities to change the casing of the phone. The outsides are becoming more tactile and as interactive as the content, i.e. the latest sensation phone from Samsung. See, Celeste Bievier, 'The Touchy-feely Side of Telecoms', *New Scientist*, 26 February 2005, p.28.
They are behavioural as most phones are now easier to use despite increased functionality and many projects are developing more emotional and intuitive interfaces. See, 'Phones are Getting Emotional', 13 September 2004, <http://www.we-make-money-not-art.com/archives/002893.php> [accessed 14 September 2005].
They are reflective as mobile phones are now seen by teenagers as fashion items. To have the latest phone is tantamount to wearing the latest fashions. See, Sölen Kipöz, 'Design Since the Mobile Phone Become a Fashion Item,' *Téxvn, Design Narratives about its Context*, <http://www.ub.es/5ead/PDF/3/Kipoz.pdf.> [accessed 30 August 2004]. And Rich Ling, "It is 'in' It doesn't Matter if You Need it or Not, Just that You Have it.": Fashion and the Domestification of the Mobile Telephone Among Teens in Norway.' <http://www.nctu.edu.tw/~u8942505/content%20of%iTeens/Fashion%20and%20the%20domestification%20of%20the%20mobile%20telephone%20among%20teens%20in%20Norway.pdf > [accessed 12 December 2004].

of deep ones'.[98] There is perhaps an argument for looking at the effect of ubiquitous technology on the body, to inform possible new cultures of technology enhanced fashion. Mob comms can provide an analogy for the ways in which consumers might use technology-enabled fashion in the future, such as:

- People might use technology in unusual and sometimes dark ways appropriating them for their own needs.[99] This would require a flexibility of use to be considered in fashion design that incorporates technology. This suggests the designer as facilitator rather than dictator.
- People like to customize personal technology. Downloadable and reprogrammable aesthetics could be considered so that the look and the meaning of garments could be changed and shared over the internet, in the same way as mob comm ringtones.
- Designers can learn about behavior with technology by observation and user tests, to inform further designs. Observational research and user testing is conducted by the mob comms community, to help understand the changing use of the technology this might prove beneficial when considering technology in clothing.[100]

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[98] Donald Norman, p.157. This is also emphasized by psychiatrist Edward Hallowell, who says that we are suffering from a distinct lack of 'human moments', as most of our communications are mediated by technology. See, D.C.Dryer, C.Eisbach and W.S. Ark,' At What Cost Pervasive? A Social Computing View of Mobile Computing Systems', IBM Systems Journal, 38, (1999), 652-676 (p. 656). It could also be said that fashion can also have this placebo affect but due to its inherent ability to communicate in close proximity could be in a position to encourage more face-to-face communications even when technology is embedded in clothing. See, Gilles Lipovetsky, *The Empire of Fashion: Dressing Modern Democracy*, trans. by Catherine Porter (Princeton, N.J: Princeton University Press, 1994).

[99] See, Ben Hammersley, 'Generation Text', *The Guardian*, 13 January, 2005, section Online, p.p. 23-24, who discusses the way that camera phones are used for nefarious purposes.

[100] Sara Berg et al used ethnographic field studies to observe the new patterns of behavior and use in teenagers with mob comms. The findings were used to inform the mobile design. The point is made that 'some social practices are relatively persistent within social groups. It follows that if these practices can be uncovered, the potential exists to propose and consider future technological solutions that are likely to be compatible with and useful in people's everyday social lives.' See, Sara Berg and others,' Mobile Phones for the Next Generation: Device

- Mob comms have changed the rules of communication. There is now less face-to-face communication. This might have an impact on the cultures of communication in fashion, once technology has been integrated. What if we can communicate with another remote garment through our clothing, will the same rules of fashion communication apply? How could technologically enhanced fashion accommodate and fit into different forms of communication – what would we want our clothing to do?
- Teenagers enjoy playing with their identity via text messaging (they can alter who they really are). How could remote communication of the self change fashion communication and personal identity?

Interaction With The Body

Architecture

Architecture is another area that could provide useful paradigms for fashion and technology as it has a history of technological integration and interaction with the body. Architecture and fashion in different ways have a very close relationship to the body:

> Both buildings and garments are made by hand and machine to enclose and yet display the human body in all its physical, cultural and psychological dimensions. Each is an extension of that body.[101]

It is a relationship that some architects have enhanced through technology-mediated interaction creating an exchange between the body and the built environment. This

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Designs for Teenagers', <http://research.microsoft.com/~ast/files/CHI_2003.pdf> [accessed 12 February 2005]

[101] Karen Frankel, 'Yes, We Wear Buildings', *Architectural Design*, 70 (2000), 94-96 (p.94).

model is relevant to fashion as it proposes technology as a conduit to physical and psychological interaction.

The architects Decostad and Rahm describe their designs as 'living environments'. [102]Their architecture is not conceived as a static shell but as a living, breathing organism that works in harmony with the body and environment, as, for example in their *Sports Hall* (Fig.1. 27). The symbiotic exchange initiated by the solar panels, illustrates that technology can be used in unison with the natural body to create a dynamic interaction.

Haus-Rucker-Co and Coop Himmelblau extended the theme of physiological interaction to include psychological interaction. At the end of the 1960s in Vienna, both proposed 'a symbiosis with anatomical structure.'[103] They experimented with the form and function of the internal body, using it metaphorically to house the external self. Concepts such as the *Mind Expander* by Haus-Rucker-Co (Fig.1. 28), aimed to stimulate the mind and body through a change in sensory perception and emphasised the psychological and physiological interaction between the body and the 'architecture'. Coop Himmelblau, in particular experimented with brain and heart monitors to capture the rhythm of the body, which they then envisioned as visual and tactile experiments, immaterial architecture: rooms without walls.

Nox is a contemporary design team that produces architecture and art projects. Illustrative of this multi-disciplinary approach is the D-Tower, a multi-media art

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[102] *Archilab: Radical Experiments in Global Architechture,* ed. by F. Migayrou and M. Brayer (London: Thames and Hudson, 2001), p. 90.
[103] C. W.Thomsen, *Sensuous Architecture:The Art of Erotic Building.* (Munich: Prestel,1998)p 38.

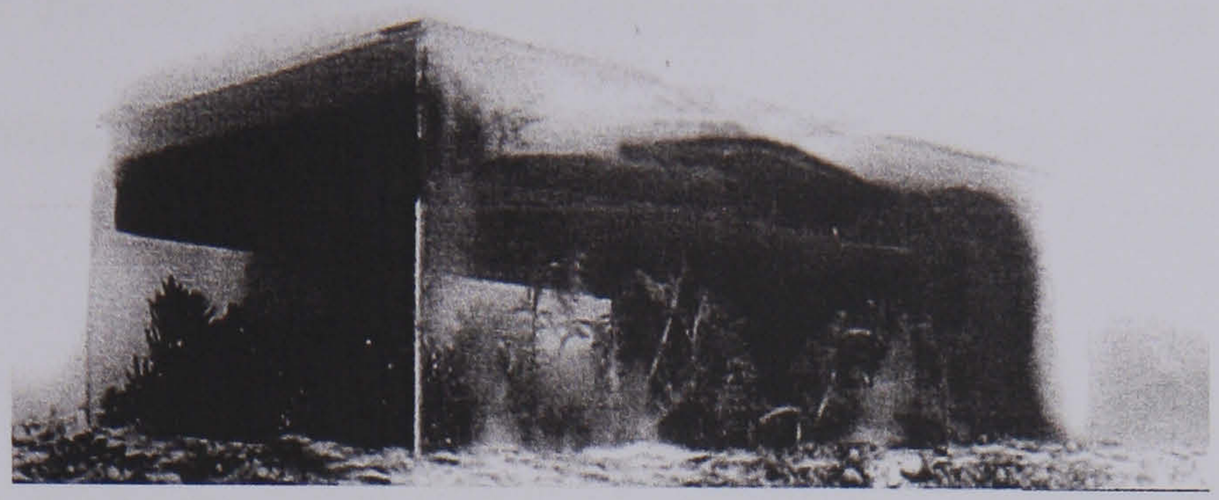

Fig.1. 27.
Decostad and Rahm's, *Sports Hall* (1998) creates a cyclical exchange of energy and oxygen. Solar energy fuels the air supply to the hall, which is absorbed by the body and transformed by biological function into carbon dioxide and chemicals. These substances are condensed on the windows and absorbed by a layer of plants which convert the chemicals back into oxygen to fuel the energy of the players.
Source: Migayrou, F., and M. Brayer, eds, *Archilab: Radical Experiments in Global Architechture,*

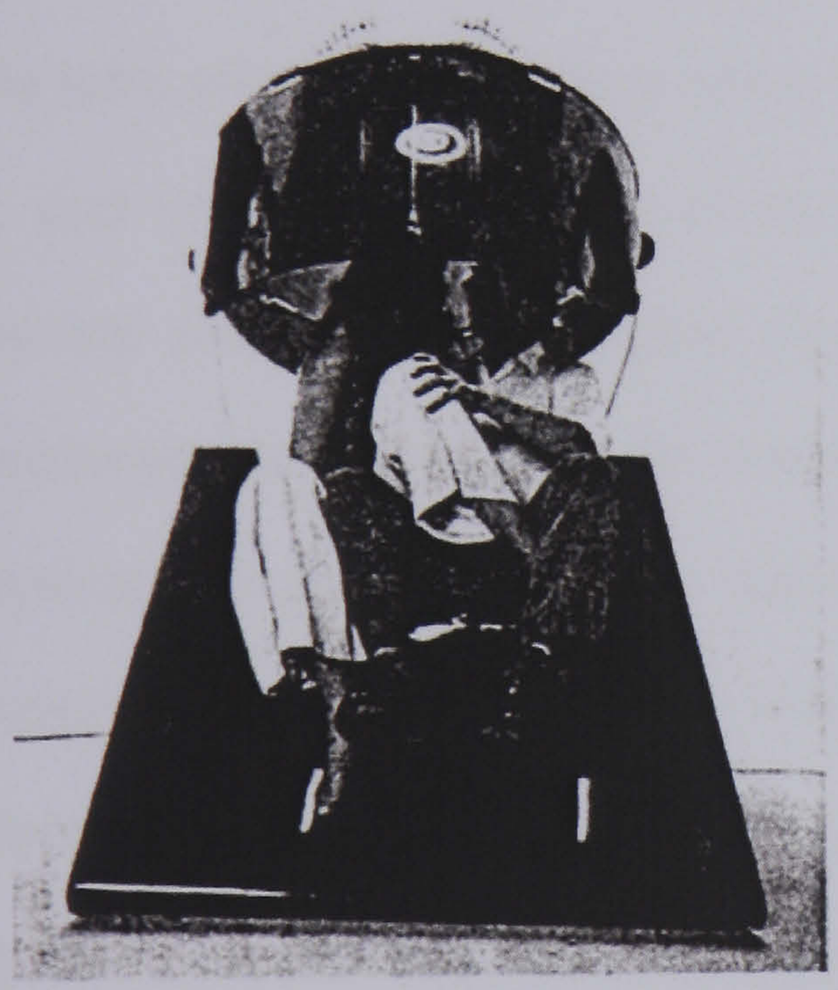

Fig.1. 28.
Haus-Rucker-Co, *Mind Expander II* (1968-9) used pulsating lights to synchronize the heart to the rhythm of the capsule, creating an almost hypnotic state and an expansion of the individual's experience of themselves.
Source: C.W. Thomsen, *Sensuous Architecture* (1998)

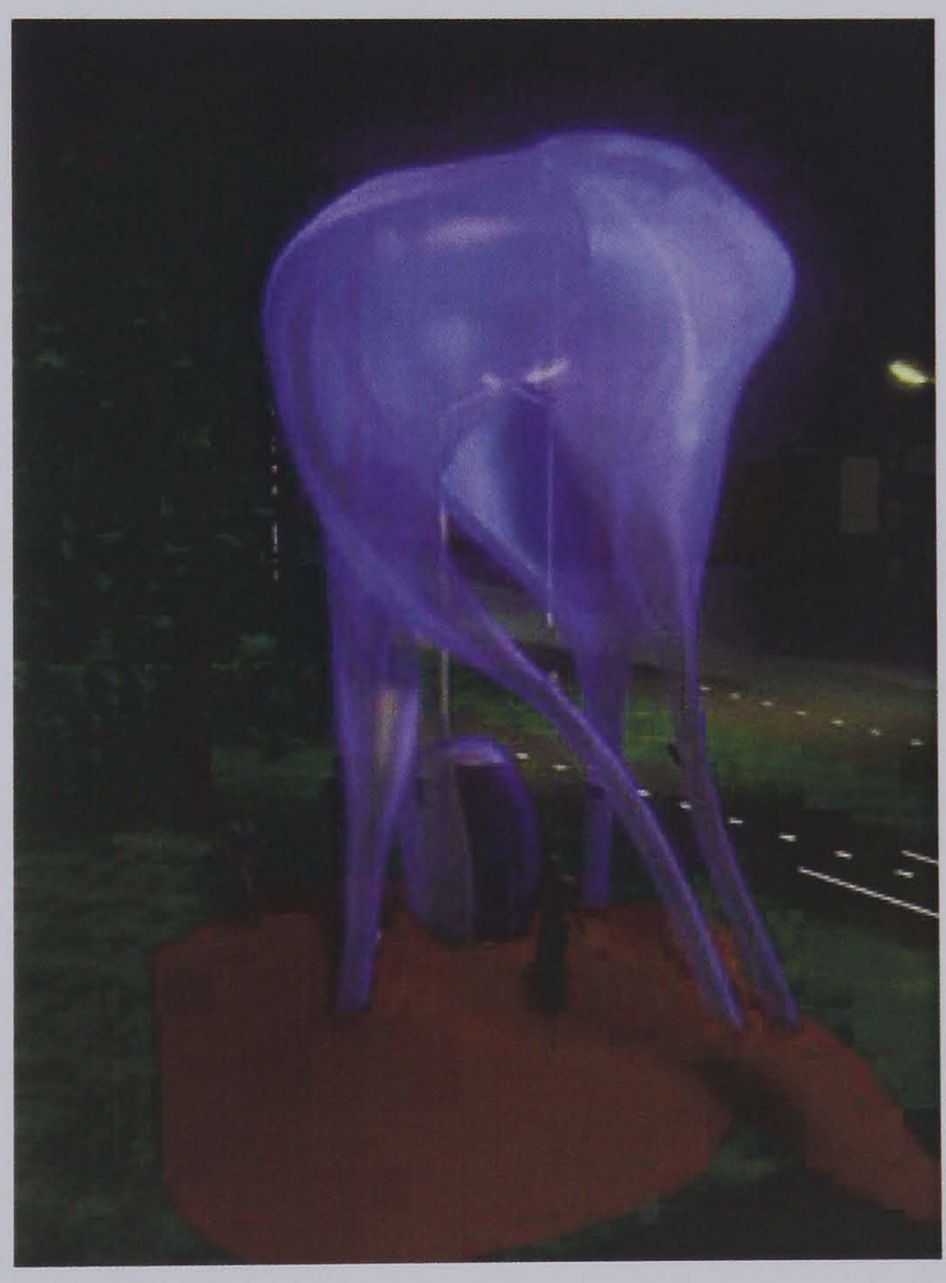

Fig.1. 29.
NOX, *D-Tower* (2003), The project gathered emotional information from the inhabitants of Doetinchem, used initially to plot a three-dimensional graph, which formed the design for the structure. Emotional maps of fear, love, happiness and hate were then represented by the changing colour of the tower (blue, yellow, red, green).
Source:
http://www.arcspace.com/architects/nox/d_tower/

installation and architectural structure. Emotional information was used to plot the emotional landscape of the people of Doetinchem on a website which visualised the emotional state of the city. Emotions determined the shape and the changing colour of the structure by interaction with the inhabitants of the city (Fig.1. 29).[104]

All four architectural projects deal with the interaction of the body, the mind and the environment and as such provide an analogy to how technology enhanced fashion could create an exchange between body, clothing, mind and environment.

Affective Computing At MIT

The term affective computing refers to computers that sense, record, analyse, respond to, and influence the user's emotional state which is inferred by physiological and physical patterns. Physiological signals such as heart rate and blood pressure are measured via wearable body sensors.[105] Video cameras and microphones capture physical indicators of emotion such as body language and speech intonation. Even though it has been shown that such simple 'measurements' can only 'infer' emotion, affective computing nevertheless provides a similar model for fashion to those of interactive architecture and the mobile phone. Affective computing provides a method to monitor emotions and create an interaction between body, technology and the wider environment. By applying this technology to fashion garments containing material technology, a form of internal to external reaction could be achieved that would be

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[104] David Littlefield, 'Twisted Ideas', *Blueprint*, January 2004, pp. 45-50
Kirsten Kiser, *NOX D-Tower,* arcspace.com, posted 20 January 2003, <http://www.arcspace.com/architects/nox/d_tower/> [accessed 26 August 2003]

[105] The relationship of physiological signals to emotion has its basis in the work of William James. See Le Doux, p.43. See also, John T. Cacioppo and Louis G. Tassinary, 'Inferring Psychological Significance From Physiological Signals', *American Psychologist,*45 (1990), 16-28.

provocative and personalized. It could also facilitate human interaction by playing on fashions role as a mediator of social interaction.

The Affective Computing Group at MIT directed by Rosalind Picard[106] uses findings of user emotional response to technology and context to inform its future developments of computer interfaces and context related products and affective wearables.[107] Some applications use emotion recognition to aid mood and memory retrieval such as the StartleCam (Fig.1. 30). Others application have more 'musical' functions such as the Affective DJ which selects music based on the wearer's mood, from a pre-selected 'emotional' playlist. Teresa Marrin Nakra at MIT has also developed an affective wearable to aid the education of student orchestral conductors called The Conductor's Jacket.[108] Another teaching aid has been developed by Katherine Blocker at MIT which uses affective computing, multimedia tools and interactive dolls to help develop the emotional learning of autistic children.[109]

By making affective computing wearable, MIT has been able to make 'the world into a lab' but it could be argued that their affective wearables are mostly 'portable' configurations of sensors and computing hardware rather than 'wearable' computers.

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[106] See, Rosalind. W. Picard, *Affective Computing* (Cambridge, MA: The MIT Press, 2000) and <http://affect.mit.edu/projects.php> [accessed 1 July 2005].

[107] The affective wearables at MIT, have two streams of development; one to facilitate continuous and intimate data collection and the other to use this information to support personal applications. Accessories have been used to position emotion recognition throughout the body via sensor technology, such as, the Expression Glasses, which measure changes in facial muscles, the Galvanic Skin Response ring and bracelet and the Galvanic Skin Response shoes.

[108] See, Teresa Marrin Nakra, 'Inside the Conductor's Jacket: Analysis, Interpretation and Musical Synthesis of Expressive Gesture' (unpublished doctor of philosophy thesis, Massachusetts Institute of Technology, 2000).

[109] The child has to match suggested emotions on the computer screen with a doll, if the doll is selected correctly it will respond with an appropriate affective response such as a giggle for happy. See Katherine Howard Blocker, 'Affective Social Quest: Teaching Emotion Recognition

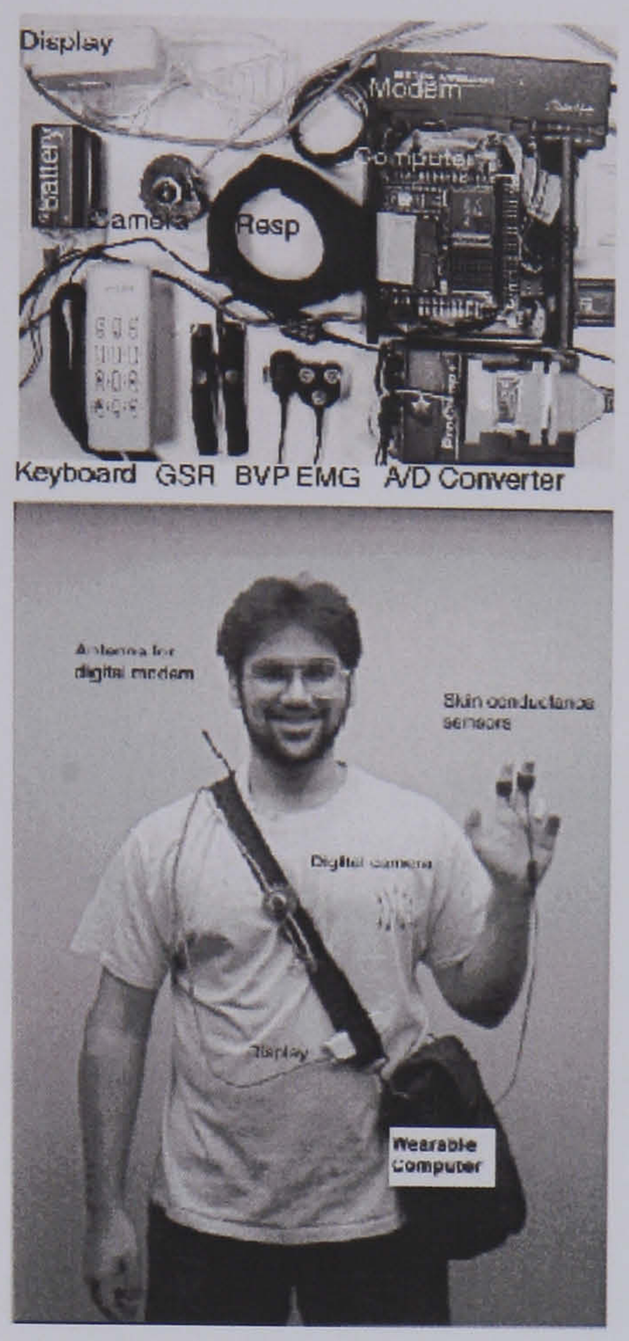

Fig.1. 30.
MIT's, *Startlecam* (1998), a wearable video camera, computer and sensor system, which records video 'flashbulb' memories based on the wearers perceived arousal level, thus creating both conscious and subconscious visual memories.
Source: http://vismod.media.mit.edu/tech-reports/TR-468/node3.html

Little effort has been made to integrate the sensors and the computers into wearable garments. The affective computer systems are carried in bags across the shoulders and the sensors attached to the body with straps over the wearer's clothing. There are a few exceptions where the integration of the technology has been addressed such as The Conductor's Jacket, The Blood Volume Pressure earring and The Galvactivator glove but there is still much work to be done to make affective computing a truly

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with Interactive Media & Wireless Expressive Toys' (unpublished master's thesis, Massachusetts Institute of Technology, 1999).

wearable and desirable proposition and to explore its myriad applications in everyday life.

Although MIT is a world leader in the development of affective computing, its research is only the beginning. Affective computing is a new area, complicated by the lack of any agreed theory of emotion and also has many practical software issues to be addressed,

> There are a huge number of problems that need to be solved ..machine pattern analysis and synthesis of affective expressions, artificial reasoning about situations that give rise to affect (for both inference and prediction), and generalized machine learning of suitable responses.'[110]

However, affective computing in clothing could provide a tool to explore emotional interaction, response and communication via the body. It could also allow garments to become more customisable or change with the mood of the wearer.

Looking To The Future – The Connected Self

The tenor of MIT's research suggests that the technology of the future will be used to create intelligent emotional interaction with computers, objects and others by imbuing our surroundings with invisible computers and sensory systems that will interact with us on a personal and emotional level. This is known as ambient technology.[111]Ambient technology is driven by competition in the electronics industry. Companies try to differentiate themselves by looking to a future where technologies would respond

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[110] Rosalind Picard, <http://alumweb.mit.edu/opendoor/200204/picard.shtml> [accessed 2 August 2004].
[111] See the Ambient Technology Research group at MIT, <http://interact.media.mit.edu/> [accessed 22 February 2005].

'intelligently' to individual needs.[112] They envision a wireless, invisible environment where computing and sensors are pervasive but not invasive: invisible, ubiquitous computing. These intelligent environments would be context-aware, turning sensory input into meaningful information to mediate the relationship between body, environment, objects and systems.

Slava Kozlov makes the point that if ambient technology is to serve the individual it must look at the complexity of personality in today's postmodern multicultural, pluralist culture. He suggests that design and technology should question the single 'self' and consider that we are dialogical, running a constant internal conversation with our many selves or 'I'-positions. He says that these are determined by our relationship and attachment to ourselves, others, objects, events, past memories and future aspirations so ambient technology must consider both physical and personal context.[113]

Again, this provides a blueprint for the way fashion can communicate both social and individual identities. Fashion has not solved the dichotomy of the individual but expressed the ambivalence we may experience in trying to understand who we are. With its capacity to communicate individual identity and to mediate social interaction, fashion could even be seen as a crucial paradigm for ambient technology. Fashion and Textile designers thereby, come to be seen as research leaders for the new technologies.[114] We are bodies within environments and if ambient technology is to address the paradox of the self it will need to interact with us both directly and through

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[112] See, Slava Kozlov, ' Human Personality: What Ambient Intelligence Will Need To Understand About Us', in *The New Everyday*, ed. by Emile Aarts and Stefano Marzano pp. 34-37 (p.34).
[113] The New Everyday, p. 34.
[114] The relevance of fashion and technology to ambient technology is shown by the inclusion of 'The Emotional Wardrobe' paper (which was published in Personal and Ubiquitous Computing) in the reading list for the Spring 2005, Ambient Intelligence program at MIT. See, <http://courses.media.mit.edu/2005spring/mas961/readings.html> [accessed 1 October 2005]

technologically enhanced clothing and communicate our 'I' personalities with the environment and to others to create a meaningful dialogue. [115]

This section of the review has shown that many of the preoccupations of contemporary emotional design are reflected in how we already experience fashion. The addition of intelligent garment interfaces to fashion or dress will be important if the vision of ambient technology is to be recognized. Fashion has much to offer the pursuit of emotional technology but conversely other types of technology and emotional design might provide methods and models for addressing technology in fashion.

Summary And Effect

As yet fashion is unable to engage with technology as there are many issues such as timing and manufacturing processes to resolve before mass integration is achievable. Culturally, technology in clothing will need to become acceptable and the development of more sophisticated 'e'-textiles and softer forms of display technology will assist this process along with the growing ubiquity of existing personal technologies such as mob comms. The work of the wearable technology sector is function-and-systems driven rather than considering issues of fashionability but by using developments in material and wearable technology and affective computing, fashion has the potential to incorporate responsive and changeable aesthetics into the vocabulary of fashion communication. Although some of the technology is in development, research from this part of the review has also been used to provide technology enablers for the practice.

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[115] The New Everyday p34-37

The context review has been used to provide a technological overview, uncover the emergence of emotion in the science, design and technology sectors and provide new ways to address the convergence of technology in clothing. It has shown that although fashion has yet to embrace the area of fashion and technology, technology has much to offer fashion and fashion is important to the development of future technologies. Fashion has the potential to provide the missing link between the body, our social worlds and the imminent rise of interactive and ambient technology.

CHAPTER TWO

Practice Review

Introduction

This review provides an overview of the main practitioners working at the intersection of art, interaction design, fashion design and technology, as it was at the beginning of the research in 2001 and as it has evolved during the completion of this study (Fig.2. 1).

Fig.2.1.
Table mapping designers included in the Practice Review to show their area of discipline, way of working and the time work was exposed in the public domain.
N.B. the discipline/environment is correct for the time that the work was produced

Table Of Designers, Practice And Dates

DESIGNER	DISCIPLINE/ ENVIRONMENT	DESIGN/ WORK	DATE	APPROACH
Hussein Chalayan	Fashion designer Working in high fashion system	Aeroplane Dress Remote Controlled Dress Shape Memory Dress	1999 2000 2000	Draws on technical expertise of collaborators to materials his ideas
Elise Dee Co	Computational fashion designer working in technical institute (MIT)	Thesis designs Puddle jumper	2000	Has technical background & interest in fashion so is able to facilitate her own designs or learn the skills required to do so
Megan Lee Galbraith	Working in technical institute (MIT)	Thesis designs	2003	Has technical background & interest in fashion so is able to facilitate her own designs or learn the skills required to do so
I.F.M (est 2001) (Maggie Orth Joanna Berzowska)	Artist/technologists Working in technical institute (MIT) and established their own company	Firefly dress (Maggie Orth, Emily Cooper, Derek Lockwood) Electronic plaid	1998 2003	Have technical background & interest in fashion/ textiles so are able to facilitate their own designs or learn the skills required to do so

DESIGNER	DISCIPLINE/ ENVIRONMENT	DESIGN/ WORK	DATE	APPROACH
50:50	Multi disciplinary group of artists, philosophers, designers	Original Love Jackets Hug Jackets	1995 2004	They collaborate with fashion designers and technical advisors to form a research group
Joanna Berzowska	Smart textiles/ full-body interaction designer working in design and technical institute (Concordia University)	Memory-rich clothing	2005	Heads multi disciplinary group who are all technically trained in both sewing and electronics
Cute Circuit (est 2004)	Interaction designers working originally at the Interaction Design Institute, Ivrea and then in their own company	F&R Hugs Kinetic dress Accessory Nerve	2004 2004 ongoing	Interaction user-centred designers. Interested in social interactions and technology. F&R Hugs involved the public in research, development and testing of prototypes.
Stijn Ossevoort	Interest in interaction design and user-inspired product design. Compass Coat designed in collaborative design research studio at the Interaction Design Institute, Ivrea	Compass Coat (part of the 'Wearable Dreams project)	2002	Interaction user centred design. Interested in social interactions and technology and creating narrative spaces around objects to involve the user. Deploys user inspired design methodology. Has engineering and design background.
Aware Fashion (Richard Etter, Diana Grathwohl and Sigmund Homolya)	Design and technology Institute (Etter based at Fraunhofer Institute IPSI, Germany although Aware Fashion was a private research project)	Aware Fashion	2005	Design and technical background, interested in social interaction and ambient technology
Fashion Victims	Interaction designers working at the Interaction Design Institute, Ivrea	Fashion Victims	2003	Interaction designers influenced by Dunne and Raby. Simple aesthetics to focus attention on reaction/mutation. Non-working prototypes and working prototypes designed to play with the characteristics of everyday objects.
Katherine Moriwaki & Fionnuala Conway	Artist/ researchers studying in the Networks and Telecommunication Research Group at Trinity College, Dublin.	Urban Chameleon	2003	Use changing garment characteristics to explore fashion and the environment.
Sompit Moi Fusakul	Jewellery designer working at The Royal College of Art	Interactive Ornaments	2002	Has technical background and collaborates with others to facilitate aspects of her work that she is not able to complete herself.

DESIGNER	DISCIPLINE/ environment	DESIGN/ WORK	DATE	APPROACH
Rosalind Picard Jocelyn Scheirer	Affective computing and electronics researchers working at a technical Institute (MIT)	The Galvactivator	2001	Technical inventors who collaborated with Philips Design and Research Wearable Electronics Team to implement the work
Lucy Dunne	Works in both wearable computing and fashion and technology. Smart Jacket produced at Cornell University, currently at University College Dublin.	Smart jacket Intelligent Expressions	2002 ongoing	Initially work was concerned with function & integration of technology in clothing. Later work explores aesthetics and technology –has technical knowledge
Thecla Schiphorst & Susan Kozel	New media artists	Whisper	2003 (1st public installation at DEAF03)	Artists who work with technology collaborators as part of a multi disciplinary group
Jenny Tillotson	Artist/ Fashion communication	Smart Second skin concept Scensory Design concept Scent Whisper brooches	1997 – ongoing 2005	Artist with fashion communication background. Works with collaborators to implement designs.

Pre- research 2001	During research 2002-2003	During research 2004-2005
Hussein Chalayan	Lucy Dunne – Smart Jacket	Aware Fashion
Elise Dee Co	Fashion Victims	Joanna Berzowska
50:50 - The Love Jackets	Sompit Moi Fusakul	Cute Circuit
The Galvactivator	IFM – Electronic Plaid	Lucy Dunne – Intelligent Expressions
IFM – The Firefly Dress	Megan Lee Galbraith	Jenny Tillotson – Scent Whisper brooches
Jenny Tillotson – 'Smart Second Skin' concept	Stijn Ossevoort	
	Whisper	
	Urban Chameleon	

The majority of development work with technology in garments was pursued not in the commercial fashion sector but in wearable computing labs, the military or the healthcare sector, with an emphasis on functional rather than aesthetic investigation. It constituted an emerging field but one that came largely from technical or interaction

institutes rather than from fashion colleges. Within the fashion industry, only Hussein Chalayan was experimenting with electronic technology in garments.[116] In addition, several researchers at the Media Lab, Massachusetts Institute of Technology (Elise Dee Co, Megan Galbraith and Maggie Orth) were looking at technology-enhanced aesthetics rather than at computing as functionality, in contrast to their colleagues in wearable computing at the Borg Lab, MIT. Gradually, over the past four years there has been a slow expansion of the field as fashion designers, interaction designers and fine artists have explored the interface of fashion and technology.[117]

Sources Of Information

As the area of fashion and technology is so new there are few books on the subject and none cover the crossover between art, interaction design, fashion and technology. An exception to this rule is the work of Chalayan whose use of technology is addressed by cultural theorists and journalists in the same vein as his other fashion work.[118] At the time of writing there were few key texts that brought together the work of the current practitioners and their work remains uncritiqued. [119] Much of the research was therefore conducted by accessing the websites of the practitioners and several personal

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[116] Olivier Lapidus, a Parisian couture designer, has also experimented with electronics in fashion but these have been inspired by telecommunications technology, featuring mobile phones and loudspeakers (similar to Philips Levis ICD+ range) rather than using technology to change the styling of a garment.

[117] Growing interest can be shown in courses at Parsons School of Design in New York, Interaction Design Institute in Ivrea and Banff New Media Institute in Canada, which encourage the expressive exploration of wearables. Parsons School of Design in New York, <http://www.parsons.edu/~fashiontech> [accessed 22 August 2005] , Design Institute in Ivrea, <http://interaction-ivrea.it> [accessed 22 August 2005], and Banff New Media Institute in Canada, <http://www.banffcentre.ca/bnmi> [accessed 22 August 2005].

[118] Caroline Evans and others, *Hussein Chalayan*, (Rotterdam : NAi Publishers, 2005), Bradley Quinn, *Techno Fashion* (Oxford, New York: Berg, 2002), pp 26-32 and 50-55 and Andrew Bolton, *The Supermodern Wardrobe* (London: V & A Publications, 2002), p.120

[119] Apart from, Suzanne Lee, *Fashioning the Future:Tomorrow's Wardrobe,* (London: Thames & Hudson, 2005*)*, published in the last stage of this thesis.

websites of designers that bring together the work of the field in a unified manner. [120] Academic papers and theses have also provided a valuable research resource by supplying detailed documentation and dates of projects and conferences and exhibitions have provided an opportunity to see some of the garments first hand.

Predecessors

Hussein Chalayan

There are fashion designers who seek to use material technology in fashion, most notably Issey Miyake, but very few have looked to electronic and computation technology to enhance fashion's aesthetic capabilities.[121] One exception is Chalayan who used electronic and material in two collections, *Echoform* Autumn/Winter 1999 and *Before Minus Now* Spring/Summer 2000. The former collection addressed speed as an inherent ability of the body and suggested that technology could be used to augment this capacity and contains the automated *Aeroplane Dress.* [122] The latter visualized our connection to nature and technology and featured two technology-enabled designs, the *Remote Control Dress* and the *Shape Memory Dress.*[123]

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[120] Of note are: Styleborg the personal website of Kerry Bodine <http://www.styleborg.com> [accessed 22 October 2003] Personal Debris, the website of Katherine Moriwaki whose work is featured in this review, <http://personaldebris.com> [accessed 21 April 2005], and Beverly Tang <http://www.beverlytang.com> [accessed 3 November 2003].

[121] See Issey Miyake's I-POC range which uses material and knitting technology to give the consumer the power to customize their own piece of the I-POC range. See Issey Miyake, Dai Fujiwara and Mateo Kries, *A-POC Making: Issey Miyake & Dai Fujiwara*, ed. by Mateo Kries and Alexander von Vegesack (Weil am Rhein: Vitra Design Museum, 2001).

[122] Sue-an van der Zijpp, 'Echoform', in *Hussein Chalayan*, Caroline Evans and others (Rotterdam: NAi Publishers, 2005), p. 62.

[123] Sue-an van der Zijpp, 'Before Minus Now', in *Hussein Chalayan*, Caroline Evans and others (Rotterdam: NAi Publishers, 2005), p. 70.

The *Aeroplane Dress* (Fig.2. 2) alluded to the aero dynamism and precision of movement of an aeroplane and demonstrates Chalayan's obsession with flight. It was developed in collaboration with the product designer Paul Topen and was constructed from resin and fibreglass, using moulding and casting techniques usually associated with the aeronautics industry. By subtly revealing and concealing areas of the body, the dress could be seen to sexualize the body, the hard casing showing the soft body beneath.[124] However, the accompanying film appeared to tell another story (Fig.2. 3). The film reaffirmed the link between the body and speed, with technology streamlining the body and providing metaphorical wings to enable the body to travel at a higher velocity.

Chalayan's *Remote Control Dress* (Fig.2. 4) developed the *Aeroplane Dress*. When first shown, a boy operating a remote control caused the hard casing of the dress to rise up and reveal soft tulle underskirts. Sue-an Van der Zijpp speculates that using the remote control system in the dress 'is a light hearted hint at the human tendency to want to control life, as well as our sometimes exaggerated expectations of technology.'[125] Quinn sees the control of the dress not as an example of exaggerated expectation of the technology but rather that it emphasizes the capacity of technology to alter the clothed body.[126] Indeed, Evans agrees, 'The plane technology is about engineering and suggests that perhaps it is not only the dress but also the self that can be engineered, fine tuned, technologically adjusted and played with.' [127] Chalayan's ideas are more about the body and the environment rather than the body and technology. However, as Quinn points out, by wearing the *Remote Control Dress* the

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[124] Bradley Quinn, *Techno Fashion*, p. 54.
[125] Sue-an van der Zijpp, 'Before Minus Now', in *Hussein Chalayan,* p. 70.
[126] Bradley Quinn, 'An Architect of Ideas', in *Hussein Chalayan*, Caroline Evans and others (Rotterdam: NAi Publishers, 2005), p. 46.
[127] Caroline Evans, 'No Man's Land, in *Hussein Chalayan*, Caroline Evans and others (Rotterdam: NAi Publishers, 2005), p. 11.

Fig.2. 2.
Chalayan's *Aeroplane Dress,* (1999) is cast in sections, of which several are battery operated. When activated by the wearer several sections respond by either revealing sections of the body or rising like wings on a plane ready for flight. Source: Caroline Evans, *Hussein Chalayan* (2005).

Fig.2. 4.
Chalayan's *Remote Control Dress*, (2000) again uses the technology of the *Aeroplane Dress* but this time the sections in the dress are activated at a distance via a remote controlled system.
Source: Caroline Evans, *Hussein Chalayan* (2005).

Fig.2. 3.
Chalayan's *Aeroplane Dress* film, (1999) shows the modelled dress shot starkly and simply in black and white against a contrasting black and white background. The activation of the dress is accompanied by the sound of a plane taking off.
Source: Caroline Evans, *Hussein Chalayan* (2005).

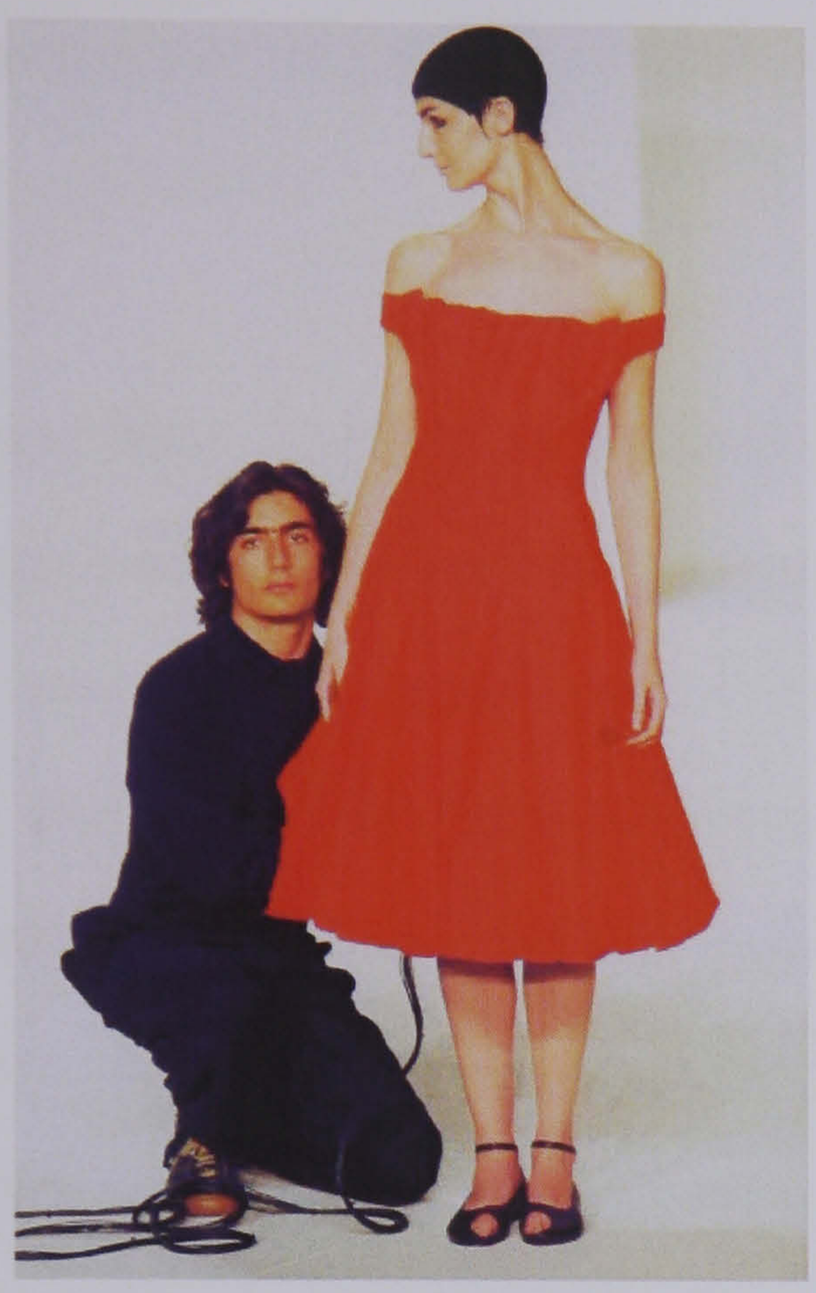

Fig.2. 5.
Hussein Chalayan, *Shape Memory Dress* (2000), utilizes shape memory alloys which change shape under the influence of electricity or heat. Source: Caroline Evans, Hussein Chalayan (2005). Source: Caroline Evans, *Hussein Chalayan* (2005).

body can not only be changed but also 'becomes a cog in the machine'[128]. According to Quinn, the integration of technology with clothing may provide a universal link between bodies and machines through communications networks.

Chalayan's *Shape Memory Dress,* from his Before Minus Now Spring/Summer 2000 collection (Figs.2. 5) responded to electrical stimulus prompting the hem of the skirt to open outwards extending its shape. The dress spoke of the intangibility of gravity as

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[128] Bradley Quinn, *Techno Fashion* p. 53.

the skirt rises, almost defying the invisible forces on earth.[129] It exposed the limitations of technology as it required an external power source to operate, but it also demonstrated that simple use of technology can be applied to garments with great effect.

Technology helps Chalayan to make conceptual showpieces. They are not wearable technology pieces to be sold for public consumption so much as experiments in the creative application of technology to fashion garments and act as ambassadors to promote this idea. The *Remote Control Dress* is the 'first wireless device to be presented as a fully functioning fashion garment'.[130] Even if it is viewed as conceptual rather than wearable, its aesthetic credentials provide a fashion rather than functional perspective on the application of wearable technology. The three dresses demonstrate that the integration of technology can provide fashion with controllable, changeable aesthetics which can be operated by the wearer or by remote interaction with others.

The *Aeroplane Dress* and the *Remote Control Dress* offered hard technology on the body at the service of the creative concept. In contrast, the *Shape Memory Dress* illustrates that technology can be integrated in a soft manner, utilizing the technology to adapt traditional fashion fabrics rather than provide the shell for the garment. Although the *Shape Memory Dress* is still reliant on outside power, the garments illustrate the beginnings of technology-mediated, mutable clothing, hinting at the future possibilities of responsive clothing.

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[129] Sue-an van der Zijpp, 'Before Minus Now', in *Hussein Chalayan,* p. 70.
[130] Bradley Quinn, *Techno Fashion* p. 52.

MIT

Responsive fashion and mutable aesthetics are explored further by Co, Galbraith and IFM at MIT who are concerned with the aesthetic and communicative possibilities of technology. They offer different definitions of the area: 'computational fashion' (Co); 'computational garments' (Galbraith); and 'electronic fashion' (Orth) but all are concerned with using technology to extend the medium of fashion and its ability to communicate and act as an interface to the world.

Elise Dee Co

While completing a Master of Science in Media Arts and Sciences at MIT in 2000 Co approached the fashion technology merger as a form of 'computational fashion'.[131] Her aim was to 'demonstrate that a synthesis of fashion and technology can be beautiful and provocative' and that technology can extend the aesthetic capabilities of fashion, an aim that is adopted in this thesis.[132] Although Co states that 'technology can and should be incorporated into fashion with sensitivity to traditional garment attributes: texture, appearance, wearability, etc.', her MA experiments all feature hard components that do not utilize traditional fashion fabrics.[133]

This is an aspect that she subsequently addressed in her *PuddleJumper* coat (Fig.2. 6), which is a material coat that uses printed electroluminescent as the display. The coat emits light when it senses moisture thus responding to rain in the environment. Her MA work explored notions of the body as an invisible space (*Perforation*), as shape and sound in space (*Silhouette*), as transferable data to others (*Hula Hoop*), as a

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[131] Elise Dee Co, 'Computation and Technology as Expressive Elements of Fashion' (unpublished master's thesis, Massachusetts Institute of Technology, 2000).
[132] Elise Dee Co, p.12.
[133] Elise Dee Co, pp. 62-63.

morphing rhythm or aesthetic that can be changed by the wearer or others (*Halo*) and as the embodiment of fantasy (*Garment Chimerical*).

In *Halo* (Fig.2. 7) a rhythm is input into the belt-like system by the wearer, which is displayed as a flashing electroluminescent light in the first unit. This rhythm is then reconfigured as it travels the length of the belt from unit to unit. The rhythm can also be controlled by others via a Palm Pilot and has the capacity to be originated by sensor input from the body. *Hula Hoop* (Fig.2. 8) is a jewellery piece that transfers and collects data from another similiar bracelet when the 'feelers' of the bracelet, touch each other and visualizes this information (a change in voltage), as a pattern on a LED matrix panel. The aim of this concept is to facilitate the communication of data between people via aesthetics. *Perforation* (Fig.2. 9) is a body piece that plays with the idea of 'transparency through physicality'[134]. It comprises hundreds of metres of fibre optic cable wrapped around the body on a supporting framework[135]. The fibre optic cables have the ability to pass light around the body from one end of each cable to the other. In this way the body piece appears to bypass the body altogether by transmitting light as a display, from the front of the piece to the back and vice versa, creating a visual void in the body of the wearer. Although Co could have used video cameras on one side of the body and an LCD display on the other to transmit a picture of the surrounding environment and thus create a hole of nothing, she resisted electronic technology in favour of using the material in its simplest form, working to its natural ability. This is an approach she calls 'truth of materials'.[136] The video to display approach has been used by the industrial design firm Ideo (Fig.2. 10) and the

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[134] Perforation, <http://www.acg.media.mit.edu/people/elise/perforation/index.html> [accessed 8 January 2003]
[135] Fibre optics have been also been used by France Telecom to produce programmable clothing. See France Telecom's Studio-creatif, <http://www.rd.francetelecom.fr/studio-creatif> [accessed 9 March 2003]
[136] Elise Dee Co, p. 50.

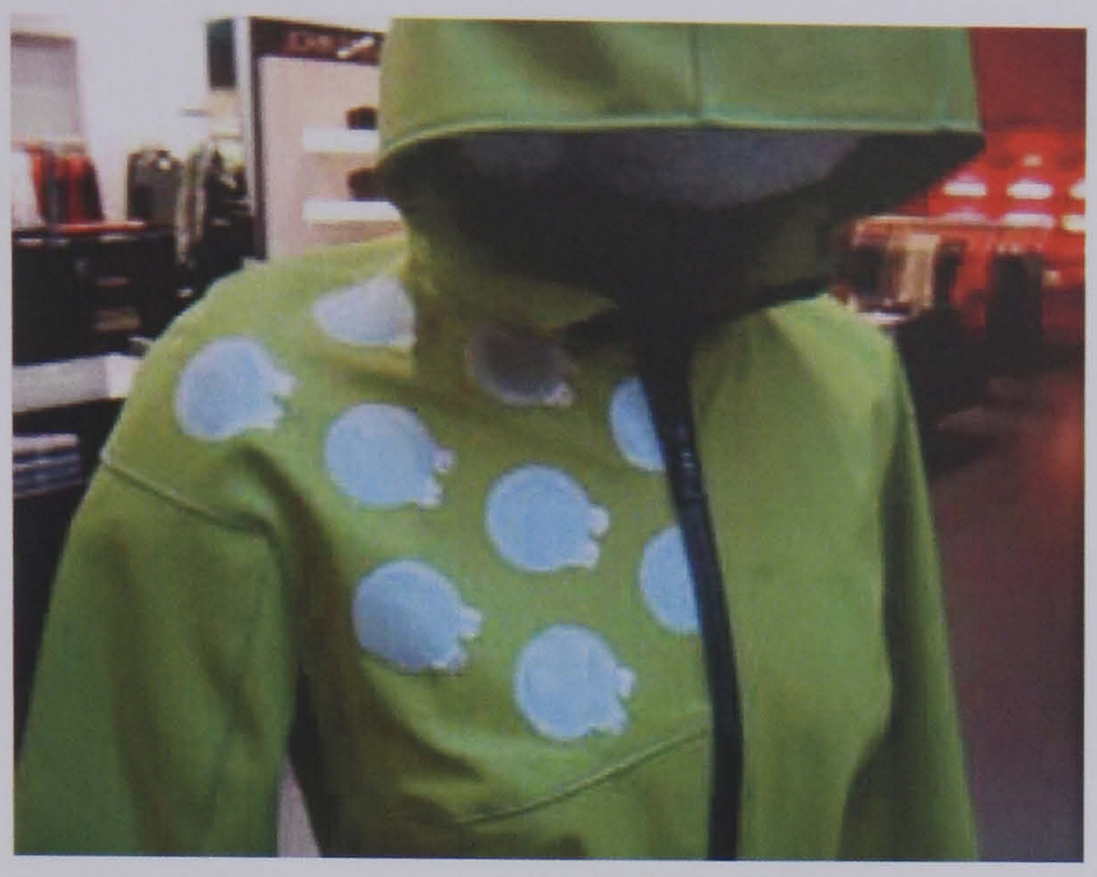

Fig.2. 6.
Co, *Puddlejumper*, a jacket that glows in the rain.
Source: http://www.personaldebris.com

Fig. 2. 7.
Co *Halo* (2000), is a belt like construction of autonomous lighting units that communicate with each other through their physical connections.
Source: http://www.acg.media.mit.edu/people/elise/

Fig.2. 8.
Co, *Hula Hoop* (2000), is a piece of jewellery that has the ability to record moments of contact with others wearing a similar bracelet.
Source: http://www.acg.media.mit.edu/people/elise/

Fig.2. 9.
In Co, *Perforation* (2000), sunlight, flashlight or a laser light is transmitted around the body to suggest invisibility.
Source: http://www.acg.media.mit.edu/people/elise/

Fig.2. 10.
Ideo's, 'Hole in the Body' top, from the 'Without Thought:e-Fashion range' (2001), a camera sends an image from the front of the body to an LCD (Liquid Crystal Display) screen on the back of the top. This project was produced by the Industrial Design group at Ideo. Source: http://www.ideo.com/portfolio/print.asp?x=50178

Fig.2. 11.
University of Tokyo's, *Optical Camouflage Project*, creates the look of invisibility using video cameras.
Source: http://www.beverlytang.com

University of Tokyo in their *Optical Camouflage* project (Fig. 2. 11).[137]

The theme of *Garment Chimerical* (Fig.2. 12) is the fantasy of human flight. It represents 'unrealistic or impossible fantasies about our bodies and our selves as exotic, changeable creatures'[138]. The display reacts to the body and features a changing male torso, which carries the suggestion of sprouting wings. The shell of the torso expands and contracts in time with the wearer's breathing and the wing tendrils unfurl as the zip on the armband is released. Finally, the curvature of the wings responds to the bend of the wearer's arm, flexing to the degree of movement in the arm. Co wrote in her thesis that she could envisage the piece responding to heart rate or even to emotions, again a suggestion of physiologically triggered aesthetics. *Garment Chimerical* is not, however, a garment so much as a poetic expression of the fantasy of flight that marries the movements of the body with the visualization of a winged body. Co recognizes that the fantasy expressed might be initiated by the garment: 'clothes themselves might dream of flying'.[139]

Co's work is characterized by responsive aesthetics. *Halo, Hula Hoop* and *Perforation* could be used to enhance or explore social interaction, as they can require others to program or trigger the display in the body pieces. *Hula Hoop* also proposes that garments could communicate, transferring and visualizing data from each other, whilst

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[137] Ideo, <http://www.ideo.com/portfolio/print.asp?x=50178> [accessed 19 April 2004], Optical Camouflage, <http://www.star.t.u-tokyo.ac.jp/projects/MEDIA/xv/oc.html> [accessed 22 October 2003]. Businessweek also reported classified research into invisibility materials by Dupont who are investigating the manipulation of light and EIC Laboratories who are researching an electrochromic camouflage material which would change colour to match the environment, <http://www.businessweek.com/magazine/content/03_30/b3843083.htm> [accessed 3 November 2003].

[138] See her work on the MIT website, <http://acg.media.mit.edu/people/elise/chimera> [accessed 8 January 2003]

[139] Elise Dee Co, p. 52. This concept mirrors the narrative of Icaris, a garment created in this research project and discussed in Chapter 3.

Fig.2. 12.
Co, Garment Chimerical (2000), is a body piece rather than a garment that comprises a LCD display screen in a backpack and a sensor armband and chin piece.
Source: http://www.acg.media.mit.edu/people/elise/chimera

Halo and *Garment Chimerical* have the potential for self-actualization, by expressing intimate fantasies and personal rhythms. These prototypes illustrate that the merger of fashion and technology could provide us with variable and new forms of visual identity based on individual body patterns, self-programming and interaction with others or the environment (*Puddlejumper*). Co looks towards a future where clothing could actively communicate but recognizes that the fashion industry has yet to utilize technology as an aesthetic tool. Co believes that the area will need to gain exposure beyond academic research before it is accepted within the fashion industry but there are also very practical issues concerning ease of manufacture and consumer acceptance that will need to be addressed before the fashion technology merger is realised.

Megan Lee Galbraith

Galbraith addressed some of the problems posed by technology for fashion designers during her time in the Aesthetics and Computation group at MIT. She developed a series of 'computational fashion' garments and concepts as part of her MA thesis that included *Elroy, Saturn Pants,* and *Twirl.* They explore both her conceptual ideas and the difficulties of technical implementation which Galbraith recognizes are a barrier that prevents fashion designers from materializing garment concepts. This knowledge was then used to inform the design of a tool for fashion designers called *Zuf* for 'computational fashion' that allowed designers to pick input and output devices from a menu, program them and see the results virtually on a computer screen. [140] This is a unique and timely approach to one of the major problems for fashion designers who might consider using technology in garments and a contribution that is rarely mentioned.

Elroy (Fig.2. 13) consists of electroluminescent panels which are embedded in the sides of a dress. Each panel is programmed to light up to depict an hour or a group of fifteen minutes. The hours of the day are shown in panels that light up over the right breast and the fifteen minute intervals flash in panels that are situated down the left leg. When the group of four, minute panels have each been lit, the first hour sequence of panels illuminates, changing its sequence after each passing hour. The programming of the display is designed to create a dynamic aesthetic and also to minimize power consumption. Thus the garment communicates information other than that relating to personal identity. By making time visual in an aesthetic pattern it creates a personal visual language which is understood by the wearer but might prove abstract to other

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[140] Megan Lee Galbraith, 'Embedded Systems for Computational Garment Design' (unpublished master's thesis, Massachusetts Institute of Technology, 2003).

Fig.2. 13.
Galbraith's *Elroy* (2003) uses EL panels and timing sequences to continue her experiments in visualizing the passing of events and time. Source: http://acg.media.mit.edu/people/megan/

Fig.2. 14.
Galbraith's *Twirl* project (2003), visualises body movement and was designed using the *Zuf* programming system. Source: http://acg.media.mit.edu/people/megan/

viewers.[141] Galbraith's explored interaction with movement and proximity in her *Twirl* project that responded to the wearer's posture and was able to detect whether the wearer is standing, sitting, or bending over by using a resistive bend sensor in the back seam of the skirt (Fig.2. 14). The design used a rotating disc motive at the hem of the skirt which spin at different speeds depending on the input of the sensor. In *Saturnpants*, a pair of Capri pants that responds to strangers, the spinning discs on the hem of the leg were triggered when they sensed another person's presence, the movement of the body controlling the direction of the discs.

All these garments show that different types of sensory information can be used as garment styling, enhancing the visual vocabulary of fashion with sound or movement in synchronicity with the wearer's or stranger's body.

International Fashion Machines

International Fashion Machines (IFM), is a start-up company formed by the Media Lab at MIT, founded by Maggie Orth and Joanna Berzowska. It develops prototypes and products based on electro conductive thread and thermochromic dyes to produce changing patterns on soft woven substrates.[142] *Electric Plaid,* (Fig.2. 15) endeavours to create a human and aesthetic interface to technology through the use of traditional materials.[143] *Firefly Dress,* (Fig.2.16) is an early IFM concept that responds to the movement of the body. As the body moves, sensors on the dress align and cause LEDs to light up under a layer of gauze material. Like *Electric Plaid*, it makes the technology integral to the design, as wiring is replaced by conductive fabric circuitry.

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[141] Megan Lee Galbraith, p. 51.
[142] See IFM, <http://www.ifmachines.com> [accessed 9 March 2003]
[143] Anne Galloway, 'Fashion Sensing/Fashion Sense', *HorizonZero*, Issue 16:WEAR, August (2004) <http://www.horizonzero.ca/textsite/phprint.php> [accessed 11 December 2004]

Fig.2. 15.
IFM's Electric Plaid (2003) is a dynamic colour change fabric which utilises thermochromic dyes and conductive thread. Source: http://www.ifmachines.com

Fig.2. 16.
IFM's Firefly Dress (1998) creates a magical relationship between body movement and light. Source: Lisa Stead

Although the work of Co, Galbraith and IFM cannot be considered fashion in a traditional sense, it has provided much of the groundwork in the field. By showing that garments can be responsive and active through a merger of aesthetics and technology, these researchers have extended the possibilities for the exploration of identity, and of social and environmental interaction in fashion. They have also recognised that technical implementation is a major block to fashion designers and one reason why technology in garment design or production has yet to happen. It is significant that there are no fashion designers in the second part of this chapter and that it is interaction designers, artists and researchers who are leading the field by experimenting with computation and material technology in clothing, developing the issues that are addressed in MIT's work with fashion and technology.

Fashion, Technology And Social Interaction

50:50

50:50 is a design and development company specializing in wearable computing. Its key concern is to instil 'social functionality' into personal devices by creating favourable conditions for social interaction. Its designers believe that that social functionality should blend into the aesthetic qualities of a garment or device to enable 'seamless and intuitive usage patterns'.[144] They also recommend a multi-layered, multi-disciplinary approach to the design of interactive devices and garments, drawing on expertise from social scientists, engineers, designers and the users themselves. In this way their approach could be seen as playful social anthropology, enhancing the studied rituals of human human interaction. [145]The *Love Jacket's,* (Fig.2. 17) respond to each other when brought face-to-face by making a sound like crickets mating. The recognition of the matching jacket is also visualized through the use of blinking LEDs. The technology within the garments is designed to be as invisible as possible by using conductive fabric to carry the electricity instead of wiring.[146] The *Hug Jackets,* (Fig.2. 18) develop the concept of the *Love Jackets* by making the interaction of two people intimate using conductive fabric to provide both a decorative pattern and an electrical conduit between the two garments. When the wearers embrace, the conductive patterning on the front of the garments aligns and passes power from one garment to another. This triggers a light and sound display in the back of the garments, a physical manifestation of a metaphorical explosion of fireworks.[147] In these designs the

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[144] Ion Constas and Despina Papadopoulos, 'Interface-Me: Pursuing Sociability Through Personal Devices', P*ersonal and Ubiquitous Computing*, 5, (2001), 1-6 (p.3.).
[145] Ion Constas and Despina Papadopoulos, 1-6.
[146] Love jackets, <http://www.5050ltd.com/loveRedux.html> [accessed 28 June 2005]; Despina Papadopoulos, 'Fashion of the Times', <http://www.5050ltd.com/articles/fashions_ofthe_Times.pdf?what=show%22%02=texte&ID=2892%20> [accessed 4 March 2004]
[147] Hug Jackets, <http://www.5050ltd.com/loveRedux.html> [accessed 28 June 2005]

technology used is simple, with the emphasis on its capacity to enhance social communication. Technology is used invisibly in a successful synergy of technology, aesthetics and social interaction.

Fig.2. 17.
50:*50's Love Jackets*, (1995) are designed in pairs, to carry, transmit and respond to the same signal. Source: http://www.5050ltd.com/loveRedux.html

Fig.2. 18.
50:50's *Hug Jackets* (2004) concentrate on the embrace of a couple rather than the discovery of a missing mate. Source: http://www.5050ltd.com/loveRedux.html

Joanna Berzowska

The theme of intimate social contact is explored further in the work of Berzowska, the Director of XSLabs, a group based at Concordia. Continuing the work she started at IFM into soft, computation and changing aesthetics, Berzowska defines the group as working from an art and design perspective to understand technological difficulties.[148] She describes her garments as 'nerdy technology prototypes (they all solve some kind of connectivity or material problem), but also social commentary artefacts.[149] XS works with technology in three ways: using existing technology; transforming existing technology; and creating new technologies. [150]

Berzowska's *Memory Rich Clothing: Second Skins that Communicate Physical Memory* range investigates the history of the garments and displays their physical memory of events. Conceptually, it comments on the trend for "Life Caching", the growing practice of photographing, annotating and saving photos of moments and events in time as a record of life. Each reactive garment/group of garments look at recording personal memory via playful aesthetics.[151] The range includes *Finger Dresses, Spotty Dresses, Feather Dresses* and the *Intimate Memory Skirt and Shirt*. The latter are social 'spies' (Fig.2. 19). The shirt records conversations via the microphone in its collar and displays the sound level or intensity of conversation through a series of LEDs. The skirt uses soft switches to detect when the wearer has been groped and again uses LEDs to display the information. The LEDs in skirt and shirt both fade over time, showing the time elapsed from the last intimate event. Other

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[148] Berzowska is one of the founder members of IFM and is now an Assistant Professor of Design and Computation Arts at Concordia University, Montreal.
[149] Katherine Moriwaki, 'From Silk to Microcontrollers', Rhizome, 4 June (2005) <http://www.rhizome.org/print.rhiz?32259> [accessed 28 June 2005]
[150] See the overview of the group at <http://www.xslabs.net/theory.html> [accessed 21 April 2005]
[151] Joanna Berzowska, 'Memory Rich Clothing: Second Skins that Communicate Physical Memory', <http://www.xslabs.net/papers/cc05-berzowska.pdf> [accessed 21 April 2005]

Fig.2. 19.
Berzowska's *Intimate Memory Skirt and Shirt* (2005) were the first experiments in this series, they are the most technology rich, relying on soft switches, microphones, microcontrollers and LEDs to implement the designs. Source: http://www.xslabs.net/theory.html

Fig.2. 20.
Berzowska's *Finger Dress* (2005) is a simple shift dress that is printed with thermochromic inks. When the garment is touched, the body heat of the hand makes the thermochromic inks becomes invisible, leaving a trace of the touch upon the surface of the dress. Source: http://www.xslabs.net/theory.html

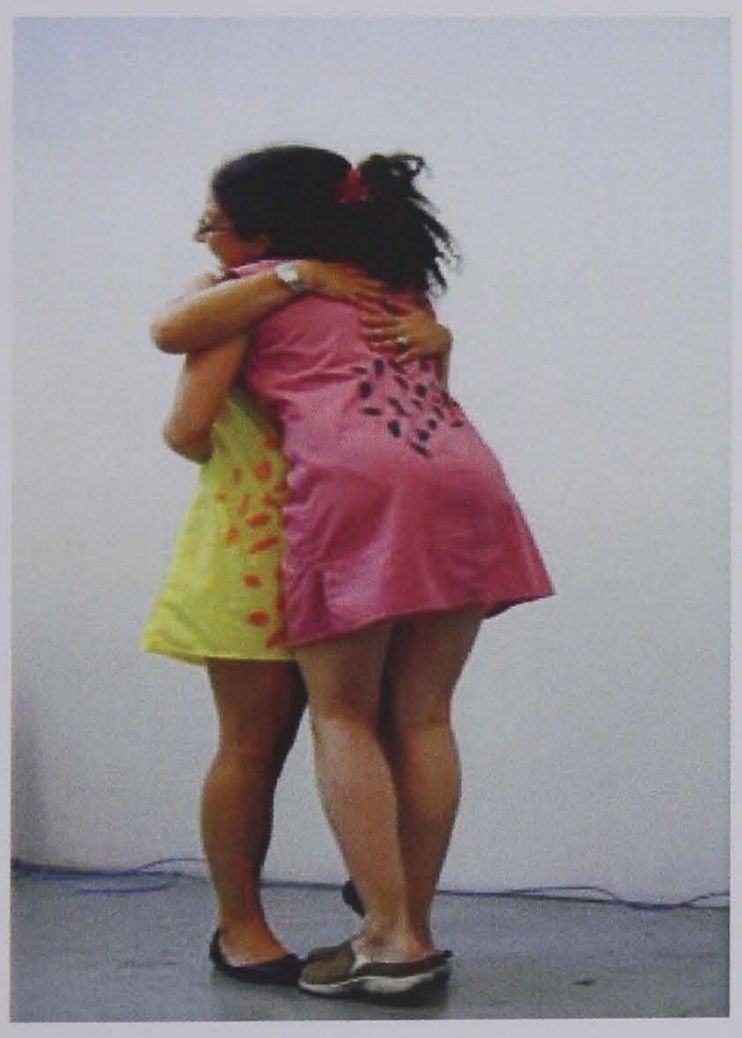

Fig.2. 21.
Berzowska's *Spotty Dresses* (2005) use the same thermochromic technology. Hugging, touching and stroking again cause the pattern to disappear, removing the camouflage and leaving the wearer ' nude' and exposed. Source: http://www.xslabs.net/theory.html

Fig.2. 22.
Berzowska's *Feathery Dresses* (2005) use fabric sensors to record the patterns of touch upon the surface of the body. This information is then expressed as a sequence of LED illuminated feathers, which have been embroidered on the dress fabric. Source: http://www.xslabs.net/theory.html

garments continue the concept of touch by simply recording the heat or movements of a hand upon the body (Figs.2. 20-22).

This series of garments all show how fashion can act as a responsive record of intimate touch, a diary of social interaction and a memory tool. They recall Co's *Hula Hoop* concept where the touch of the body pieces initiates a transfer of data. However, in these designs the emphasis is on contact between people without the mediation of the technology. Significantly, the *Spotty* and *Feathery Dresses* were made in triplicate, rather than as stand-alone pieces, defining a social interaction as communication between more than two people. Berzowska describes the interaction of groups of garments and bodies, brought together physically rather than virtually, as 'social choreographies of touch', a trend seen in the use of wearable wireless or infrared technologies, as in 50:50's *Love Jackets*.[152]

Cute Circuit

Cute Circuit is an interaction and product design lab founded in 2004 by Rosella and Genz, two former MA graduates from the Interaction Design Institute in Ivrea, Italy. They define interaction design as assessing three parameters: technical feasibility, economic sustainability and emotional desirability. They apply this framework to the research and development of products and services, and describe their work as 'starting from desires' rather than from technology and advocate a user centred approach to design.[153]

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[152] Joanna Berzowska, p. 7
[153] Cute Circuit, <http://www.cutecircuit.com> [accessed 23 October 2004]

Their *F+R Hug,* shares with many contemporary designers of fashion and technology a fascination with touch (Fig.2. 23). In *F+R Hugs* touch is transmitted over distance via sensors and remote communication rather than the intimate touch of 50:50 or Berzowska. Sensors inserted in the garments measure the pressure and length of a hug, skin warmth and the heartrate of the sender. This information is transmitted wirelessly to a loved one's phone, when their name is whispered. The phone then acts as a mediator, sending the data to the receiving garment where the characteristics of the hug are replicated in the garment actuators, sending a distant hug from one person to another. This concept uses sensory technology to communicate the interaction and the identity of the sender rather to represent it. The emphasis is on the emotional nature of the interaction and the technology is used primarily for communication. The aesthetics of the garment are an integral element but are not the first concern. This different emphasis of design requires a different methodological approach from

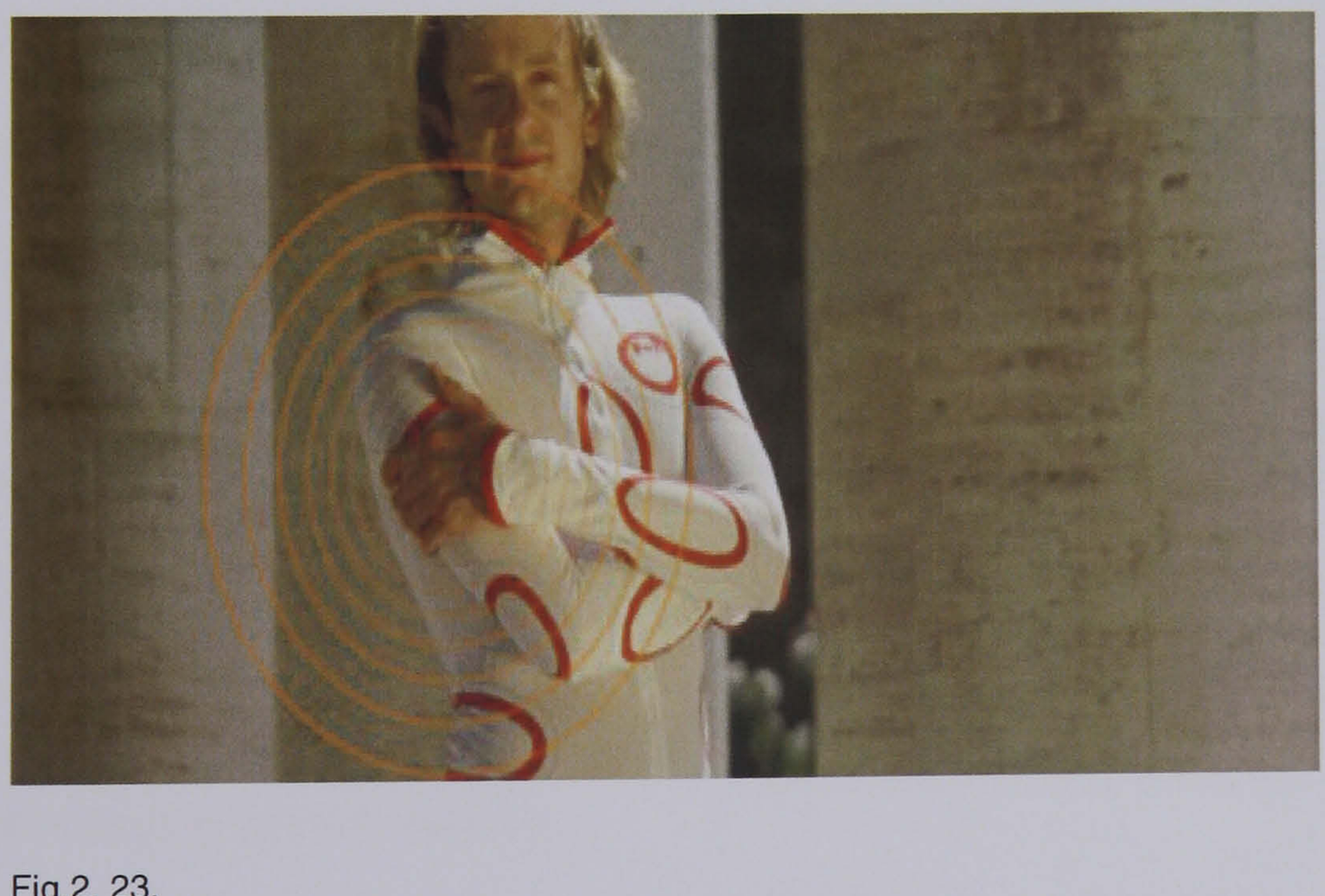

Fig.2. 23.
Cute Circuits *F+R Hugs* (2004) utilizes a system of sensors and actuators within male and female garments, to gather and send hug data from one garment to another.
Source: http://www.cutecircuit.com

conventional fashion. *F+R Hugs* featured extensive user participation at every stage of design development. Users were involved in hug sessions where a taxonomy of hugs was developed to decide on the placement of sensors and actuators. They were also interviewed and consulted in design sessions, they completed questionnaires, and finally tested the products. In this way, the information acquired was filtered back into the iterative design process. This is a very different way of working from a traditional fashion approach that dictates desires rather than investigates them. It would require a fine balance between the wishes of the public and the creative input of the designer but could ultimately lead fashion and technology into newer and more commercially acceptable avenues.

The *Kinetic Dress,* (Fig.2. 24) remains black whilst the wearer is stationary but as the wearer becomes more active the dress lights up with blue circles of electroluminescent wire, providing a moving display of light. It is a simpler example of body/garment responsive aesthetics than Co's *Garment Chimerical,* which responds to several body actions, but its power is in its very simplicity. It illustrates that fashion can use technology sparingly and subtly to produce an aesthetically acceptable garment that could be considered fashionable. *Accessory Nerve,* (Fig.2. 25) is a work in progress that uses the physicality of the garments to provide the interaction. It is a sleeve accessory that responds to text messages by creating pleats on the fabric of the sleeve. The wearer can transmit a message back to the sender by stroking the sleeve to erase the pleating. It shows a very subtle use of traditional garment characteristics to enhance technological communication.

Cute Circuit adapts the physical properties of the garment. Traditional garment devices such as pleats, gathers and pockets and changes in fabric texture can signal incoming or outgoing information from the wearer or garment to others. Although shape and

Fig.2. 24.
Cute Circuit's *Kinetic Dress* (2004) borrows aesthetic styling from the Victorian period and visualizes body movement.
Source:http://www.cutecircuit.com

Fig.2. 25.
Cute Circuit's *Accessory Nerve* (ongoing), is a sleeve that moves up and down when it detects an incoming text message.
Source: http://www.cutecircuit.com

texture change is technically more difficult to develop at present than visual communication, it would allow designers to use the traditional vocabulary of garment construction to signal garment response, rather than resorting to lights and buzzers, both of which are alien to fashion designers and to the public. As a group of concepts, the Cute Circuit projects show how fashion and technology could develop in the future: subtle, sensory and interactive, in contrast to many of the projects featured in this review, which although interesting conceptually, still look more like wearable art that traditional clothing. For example, the work of Celine Studer, a student at Hyperwerk, translates as wearable performance art rather than fashion (Fig.2. 26.).[154] Cute Circuit's work also provides a user centred approach to the design of technology on the body, an emphasis that is also evident in the work of Stijn Ossevoort.

Fig.2. 26.
Studer's *Exploding* , from the Fashionation project (2004), projects text messages, signs and phrases onto the surrounding environment and to accomplish this task, the dress houses a large projector and batteries. This has the effect of moulding the dress around the technology and creating an unwearable and unwieldy silhouette.
Source: http://www.fashionation.info

[154] Hyperwerk, is an interdisciplinary department at the University of Applied Sciences in Basel, Switzerland, bringing together design, technology, management and interaction. Fashionation was developed by a multi-disciplinary team headed by Studer. See Fashionation, <http://www.fashionation.info/> [accessed 3 July 2005].

Stijn Ossevoort

Ossevoort's *Wearable Dreams* project uses co-creation techniques to include members of the public in the designing process. First, he asks the volunteers questions about their shopping habits and their favourite outfits. Then they are encouraged to create a collage describing a favourite outfit and asked to explain a favourite garment for a special occasion. Next they focus on their favourite wearable object which can be a garment or a piece of jewellery etc and create a personality for them. The final phase is to construct a frightening scenario that the garment could help solve. From this information he designed the project garments. His *Compass Coat* (Fig.2. 27), contains EL wires which light up when they face north and therefore act as a compass to help navigate dark situations.

Fig.2. 27.
Ossevoort's *Compass Coat* (2002) is a concept derived from a story about Colin, a woolly hat who is able to find his way out of a dark forest by looking at moss growing on the north side of trees.
Source: http://nathan.com

This approach seeks to enrich the wearer's relationship with the garment by helping a user group to generate garment stories. It moves away from designing garments for generic groups of people and instead creates personal narratives that are inspired by the participants. This could provide an interesting approach to the integration of technology within clothing but further involvement of the wearer in the design process would require a careful balance of design power to avoid bland 'design by committee'.[155]However, Ossevoort emphasises that the consumers provide inspiration rather than solutions.[156]

Social Commentary

The works discussed next are academic group projects named by project rather than designers. They use technology in garments to comment on darker emotional subjects and interactions, such as the urban environment and its capacity for pollution in many forms. In this way they are extending another function of fashion: to provide social commentary.

Aware Fashion (Fig.2. 28) like Cute Circuit's *Accessory Nerve*, visualizes mobile phone activity. Whereas *Accessory Nerve* represents personal text messaging through garment change, *Aware Fashion*, feeds from all mobile phone use. Etter, Grathwohl and Homolya, developed the concept as a private project, it features a plain shirt that

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[155] See Donald. A. Norman, Emotional Design: Why We Love (or Hate) Everyday Things (New York: Basic Books, 2004), p.97, who recommends user involvement when addressing usability issues but argues that the reflective and visceral attributes of design are best served by the vision of the designer rather than the wishes of the many.
[156] Stijn Ossevoort presented his work at a Design for the Twenty First Century cluster workshop, held in Bristol, September 2005 and at Avantex 2005, in Frankfurt.

has the addition of fibre optic strands and antennae embedded within its sleeves and pockets [157]. When the shirt detects mobile phone activity, the fibre optics glow at the end of the sleeve creating a subtle display of the invisible communication environment. [158] This shirt has a practical application, as staff in cinemas, theatres and restaurants could use it unobtrusively to detect mobile phones that have been left on. More poetically it senses the presence of others or could be seen as a dark reminder of possible dangers of electromagnetic radiation.

This theme is continued in the work of *Fashion Victims*, an earlier project consisting of a series of garments and accessories designed at the Interaction Design Institute in Ivrea (Figs.2. 29). They too explore and visualize the invisible world of mobile communications and are inspired by Dunne and Raby's work on making invisible electromagnetic environments visible. Mobile phone activity is visualized by a blood red stain on the surface of the bag or shirt, a strong metaphor for communicating the possible dangers of electromagnetic energy.[159]

Urban Chameleon, a project by Katherine Moriwaki and Fionnuala Conway in Dublin, visualises other forms of urban pollution as decorative elements on a series of skirts (Fig.2. 30).[160] *Touch* a skirt that simply shows the touch of another by the use of thermochromic inks in a similar way to the work of Berzowska. The touch of a hand

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[157] Although Etter is currently a scientific staff member at Fraunhofer Institute IPSI, Germany, working within the Ambiente Group.
[158] Aware Fashion, <http://www.richardetter.net/awarefashion.php> [accessed 28 June 2005]
[159] See Fashion Victims, <http://fashionvictims.org> [accessed 21 November 2004] fashion. See Urban Chameleon, <http://www.mee.tcd.ie/~moriwaki/chameleon/index.html> [accessed 22 November 2005] and NTRG, <http://ntrg.cs.tcd.ie/> [accessed 25 October 2005]
[160] Moriwaki and Conway are PhD students in the Networks and Telecommunications Research Group (NTRG), at Trinity College Dublin with backgrounds in music, film, interaction design and fashion. See Urban Chameleon, <http://www.mee.tcd.ie/~moriwaki/chameleon/index.htm>[accessed 22 November 2005] and NTRG, <http://ntrg.cs.tcd.ie/> [accessed 25 October 2005].

Fig.2. 28.
Aware Fashion's shirt (2005) visualizes mobile phone activity by glowing. Source: http://www.richardetter.net/awarefashion.php

Fig.2. 29.
Fashion Victims (2003) use very simple aesthetics for the shirt and bag to concentrate attention on the interaction with the invisible environment. Source: http://fashionvictims.org

Fig.2. 30.
Urban Chameleon (2003) explores other forms of urban pollution such as air and noise quality and evasion of public space, using the display of information as a decorative element of a series of skirts. Source:http://www.mee.tcd.ie/~moriwaki/chameleon/exhibition.html exhibition

leaves an outline of the hand on the skirt. *Speak* measures the noise in the environment and reacts by causing the skirt to vibrate. The microphone that measures the urban sound is contained in a matching scarf. *Breathe* uses different levels of air quality to trigger colour change in the skirt.

All three projects, *Aware Fashion, Fashion Victims,* and *Urban Chameleon* demonstrate that technologically enhanced garments can be used to explore and interact with the invisible environment. Perhaps *Urban Chameleon* comes closest to a form that would be wearable and acceptable to the fashion industry. The other projects approach the display of information as unobtrusive details of garments or strong metaphors that could be adapted for fashion garments. All the projects investigated dark themes, such as electromagnetic pollution, an atypical inspiration for fashion but one that may prove timely at a moment when the dangers of mobile phones are topical and relevant to clothing if mobile phone technology becomes integrated into garments. In this way, the facilitating technology critiques mobile phone technology: technology is used to comment on technology.

Body-responsive Aesthetics

This chapter has reviewed various types of responsive aesthetics that are triggered by intimate and remote social interaction with others. This section looks at the most intimate relationship of them all: the representation of the internal body mediated by material technology.

Sompit Moi Fusakul

Fusakul is a jewellery designer who works with responsive material technologies triggered by heartrate sensors. Her PhD research at the Royal College of Art, London, culminated in a series of body activated adornments, entitled *Interactive Ornaments*. Fusakal's aim was to visualise changes in body physiology in her jewellery. She was inspired by nature's ability to adapt and change, according to adjustments in the environment or to provide protection from predators. In this way she hoped that her work could act as a bridge between art and science.[161]

For *Vein 2* (Fig.2. 31), Fusakul presumed that a rise in temper would result in a rise in blood pressure and that this alteration could be shown by a change in colour from blue, for calm, to red for excitement. A heart rate monitor, strapped to the chest of the wearer, measures beats per minute and sends the data to the necklace to trigger the colour change. Sixty beats per minute equals blue and a rise is reflected in both blue and red fibre optics glowing until a heart rate of a hundred and ten beats per minute triggers an all red display. *Aliform* (Fig.2. 32) consists of nine, oval, three-dimensional shapes, resembling an exaggerated venus fly trap. The neckpiece uses Shape Memory Alloy NiTiNol wires to move the shape mechanism. It is designed to deliver heat to each shape after groups of five heartbeats are detected, triggering the forms to open and close in sequence. The wire technology used in *Aliform* is the same as used by Chalayan in his *Shape Memory Dress* to activate the flowering of the skirt.

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[161] Sompit Moi Fusakul, 'Interactive Ornaments', (unpublished master's thesis, Royal College of Art, 2002), Chapter 5, p. 39

Fig.2. 31
Fusakul's *Vein 2* (2002), is a fibre optic necklace that changes colour to reflect changes in the wearer's emotional state. Source: http://www.personaldebris.com

Fig.2. 32.
Fusakul's *Aliform* (2002), is a neck piece that utilizes heart beats to trigger a change of shape. Source:
http://www.personaldebris.com

Fusakal's pieces rely on contact and communication with the body to activate a response. She says 'they are only alive by the wearer'.[162] Although one might think that the jewellery would give too much information away, in fact there is no direct correlation between defined emotions and heart rate in the project. Nevertheless, Fusakal hopes that they could be worn in everyday situations and in this way provide an aid to social communications.

Other body responsive jewellery includes Ideo's *Pulse Necklace* and *Bracelet* (Fig.2. 33), and MIT's *Affective Earring*, which glows according to blood pressure volume.[163] The *Galvactivator* glove has also been developed within the Affective Computing Department and uses galvanic skin response sensors to trigger an LED, allowing the wearer to monitor her or his stress levels (2001).[164] A twist to this concept is the *Heartthrob Brooch*, developed for top American jeweller, Harry Winston, by MIT's Michael Hawley.[165] The brooch registers heartbeats and sends the information via a radio signal to a transmitter in a purse carried by the wearer. The transmitter sends this data to the internet to allow the wearer to record a chart of their heart beats over the course of the day.

Lucy Dunne

Lucy Dunne has used body signals to activate garment responses in her MA research at Cornell University and subsequently to trigger aesthetics in her *Intelligent Expression*

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[162] Sompit Moi Fusakul, Chapter 6, p4.
[163] See Ideo, <http://ideo.com/portfolio/print.asp?x=50178> and Affective Jewellery at MIT, <http://affect.media.mit.edu/AC_research/projects/affective_jewelry.html> [accessed 19 April, 2004].
[164] See the Galvactivator, <http:www.media.mit.edu/galvactivator/> [accessed 29 July 2003].
[165] See Heartthrob, <http://www.findarticles.com/cf_dls/m0cgN/n3382/20460746/p1/article.jhtml> [accessed 19 April 2004].

range of garments. Dunne's interests at Cornell were purely utilitarian and body sensors were used to activate functions, such as heat pads in her *Smart Jacket.* [166] In contrast her subsequent work uses technology to visualise physiological responses in evening gowns. Her *Pulse Gown* (Fig.2. 34) uses heartbeats to activate a red light in the area around the heart and her *Alert Gown* uses galvanic skin response to display visually the level of attention or arousal of the wearer.[167]

Whisper

Whisper, is a large collaborative project directed by Vancouver based media artists Schiphorst and Kozel. The garments contain body sensors, such as heartrate and galvanic skin response, which are used to extract physiological data as triggers for different visual and auditory displays and sensory experiences (Fig.2. 35). Some displays are located on the garments as LEDs and others are situated in the environment, such as video projection and audio speakers. The networked garments whisper to each other when they are in close proximity, sharing signals between the bodies of the participants. The piece investigates the generation and representation of personal and collective data, serving as a testing ground for new forms of group interaction.[168] Whisper is not concerned with the wearability of the garments, or even whether they are in the traditional sense garments. Indeed, they are described as 'a cross between theatrical costumes and body sculpture' on the website. Rather, the garments are at the service of the concept to collect and output data. As Moriwaki

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[166] Lucy Dunne, Susan Ashdown and Eric Mc Donald, '"Smart Systems":Wearable Integration of Intelligent Technology', <http://www.lucydunne.com/smartsyatemsICEWES2002.pdf> [accessed 2 July 2004]
[167] See Intelligent Expression, <http://www.lucydunne.com/intelligent%20expression.htm> [accessed 21 April 2005]
[168] See Whisper, <http://www.lab.v2.nl/projects/whisper.html> [accessed 14 December 2004]

Fig.2. 33.
Ideo's, *Pulse Necklace and Bracelet* . Source: www.ideo.com/portfolio/print.asp?x=50178

Fig.2. 35.
Whisper (2003), is a group of networked garments and hand held devices that operate within a multi-media environment. The garments function more as wearable art than fashion items. Source: http://www.lab.v2.nl/projects/whisper.html

Fig.2. 34.
Dunne's *Pulse Gown* (ongoing), shows heatbeat as pulsing red light. Source: www.lucydunne.com

states, this system of networked garments is imbued 'with the potential to integrate emotive and intimate elements into the network communications of the future'.[169]

Jenny Tillotson

Jenny Tillotson is an artist whose work seeks to modify and express emotions using the sense of smell and to use scent to communicate remotely over 'a wireless web'. Tillotsons *Scentsory Design*® proposes that emotional wellbeing and health can be enhanced via a multi-sensorial approach to design. Technology and textiles are combined to create garment and accessory systems that stimulate the olfactory system which in turn interacts with body physiology and psychology. Tillotson's work is based on small microfluidic devices which are able to pulse tiny amounts of fragrance in response to bodily or environmental changes.[170]

Tillotson's work began with her PhD research into a '*Smart Second Skin*', a garment concept which proposed a dress that could react to changes in body temperature by releasing scent carried in tiny tubes embedded in the garment. This idea is now being developed further into a textiles scent delivery system that combines microfluidics with microtubes integrated in a fabric membrane and individual scent capsules that would allow the scent to be refilled and customised. When the textile is fully developed it could be capable of reacting to emotion via physiological sensors, using scent to

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[169] Katherine Moriwaki, 'Between the Skin and the Garden', *HorizonZero*, Issue 16:WEAR, August (2004) <http://www.horizonzero.ca/textsite/phprint.php> [accessed 11 December 2004]

[170] 'Microfluidics is a new technology, which involves the design and production of devices that deal with extremely small volumes of fluids…Microfluidics is the generic technology of manipulating fluids on a chip, including the integration of pumps, valves, mixers and reaction chambers that enable the fabrication of microreactors and lab-on-a-chip devices.' See Jenny Tillotson, 'Scent By A Wireless Web', a paper presented at the Wearables Futures conference 14 - 16 September 2005, University of Wales and Jenny Tillotson's website, <http://www.smartsecondskin.com/> [accessed 20 January 2006].

manipulate mood. To date the technology has been used to create 'scent-on-a-chip' fashion accessories which utilize microfluidic components, scent reservoirs and nozzles engineered onto a microchip and embedded in a series of brooches and a bag. *Scent Whisper* (Fig. 2. 36) links two brooches; a spider brooch that contains a remote sensor and a bombardier beetle brooch with a scent dispensing unit. The wearer whispers a message into the spider brooch which reacts to the change in humidity and temperature by triggering a wireless signal which is sent to the beetle brooch. The beetle brooch reacts to the signal by releasing scent. A *Variable Scent Bag* allows multiple scent output by using several microfluidic devices activated by switches on the front of the bag. In the future this technology could also be used to dispense ventolin to asthma suffers, to create a barrier to repel mosquitoes and use smell to communicate. Although Tillotson's work uses technology that responds to the body to dispense scent rather than to change aesthetics it does provide the possibility of another sensory and emotive layer to technology enabled communication in clothing.

Fig. 2. 36.
Tillotson's *Scent Whisper* (2005), a series of brooches that can transmit a scent message wirelessly from one to the other.
Source: Jenny Tillotson

The jewellery, garments and concepts in this section demonstrate the aesthetic potential for fashion and technology to use the body signals of the wearer, to create an intimate relationship between the garment and the body. It could be argued that this form of body-to-garment communication has the potential to provide new levels of aesthetic communication, showing the internal identity of the wearer on the external surface of a garment. In addition, the transfer of data, and the aesthetic output between bodies, could allow the communication of personal aesthetics between groups of people, resulting in new forms of group identity and social interactions. When this information is also networked to interactive environments, as in *Whisper*, the sensory garment can be used to generate displays away from the body, projecting the internal state of the individual into a virtual space, where they are realized as aesthetic and sensory displays. Although this area appears to be the most futuristic for fashion and technology, the development of sensory garments has been happening in the healthcare and military sectors for years. The designers and artists are merely adding new output to the input of the sensors, so that the data is represented on garments and in environments rather than on computer screens.

Summary And Conclusion

All of the work surveyed so far raises a number of key technical, conceptual, methodological and aesthetic issues. Without exception, the technical implementation in all of these projects has proved time consuming and sometimes very difficult. Galbraith suggests one solution to this problem in the development of her *Zuf* system, which enables non-technical designers to implement their own technology by allowing them to see the results of their choices virtually before spending time materializing

ideas. Galbraith, Co and Berowska suggest that designers acquire as many technical skills as possible so that they are able to manipulate the technology to their own ends with greater dexterity. Berzowska asserts that this fundamental knowledge is required to enable a practitioner to treat technology as an artistic medium.[171] This point of view is in stark contrast to the reality of the fashion industry where levels of technical know-how and control of the manufacturing processes are varied.[172] If the fashion industry is to embrace technology in the future a new role might emerge, that of a technical advisor/ implementer who works in parallel with the designer, similar to the way a designer and pattern cutter can work closely together in some levels of the fashion industry. However a designer would have to chose to work this closely with a technologist.

The technologies available to designers are still very limited and require technical understanding, with the exception of thermochromic dyes which use traditional screen printing or dying processes. All the garments discussed here use readily available forms of technology such as LEDs, electroluminescence panels or wire or thermochromic ink for colour change. Others rely on sound or movement to provide decorative and emotive qualities to the garments. Chalayan and Fusakal are the only designers who have explored shape change with SMA wire. Shape change is still the most difficult aesthetic quality to achieve and will require the development of new technologies such as shape memory polymers to come to fruition. However the work started by Cute Circuit with their *Accessory Nerve* sleeve shows the potential for more subtle aesthetic outputs by augmenting traditional garment construction techniques.

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[171] See XS, <http://www.xslabs.net/theory.html> [accessed 21 April, 2005]

[172] In a top fashion house the designer spends perhaps a fifth of their time actually designing and then assign the designs to others to implement. The designer supervises the process working closely with pattern cutters and machinists. Designers for the mass market often send designs and garment specifications to factories abroad with minimal control of the pattern cutting and manufacturing process.

Different approaches to the integration of the technology will also affect the application and acceptability of the aesthetics in the garments. Whereas some practitioners start with the technology and view its integration as part of the conceptual development process, exploring both technical and conceptual problems, others such as Chalayan are led first and foremost by aesthetic considerations. *Aware Fashion*, *Fashion Victims* and *F+R Hugs* by *Cute Circuit* all function as everyday garments, the aesthetics are plain and the technology integrated in a subtle and invisible manner. Other designs such as those by Fusakul, *Interactive Ornaments,* Co, *Hula Hoop and Halo* and 50:50's *Love Jackets* demonstrate aesthetics that operate within their own realms of design. Although the aesthetics of Fusakul's work are unashamedly extreme the pieces as conceptual jewellery pieces in the same way that Chalayan's dresses are acceptable as showpieces. The design of the other garments vary from conceptual pieces that function as wearable art but not as fashion garments, as in the case of the *Whisper* project, to aesthetics that work conceptually but could be improved through further development. I consider the most successful balance of aesthetic communication and technological responsive function and social interaction to be 50:50's *Love Jackets*. They demonstrate a successful symbiosis of aesthetic decoration and technological function. For most of the designers reviewed here, it is a compromise between aesthetics, technology and concept.

Formative Influence On The Emotional Wardrobe

At the beginning of the research in 2001 I looked to the work of Chalayan, Co, Galbraith[173], IFM and 50:50 for inspiration. At the time IFM's *Firefly Dress* and

[173] Galbraith's work in progress was available on the internet before her thesis was submitted.

Chalayan's *Shape Memory Dress* were the only examples recognisable as wearable and attractive garments (rather than hard accessories as Co). Although Co, Galbraith and 50:50 (early *Love Jackets*) had considered the look of their garments and body pieces, I felt that the aesthetic sensibility of their work could be enhanced to include softer fabrics that work within a fashion vocabulary.

The early Practice Review thus uncovered a need for further integration of technology with soft fabrics to create tactile and attractive garments. It also showed the potential of using electronics, computing and material science to create programmable and interactive garment displays. The latter Practice Review enabled me to position my research within the field of interaction design, 'computational fashion', and art and technology research. Retrospectively, I found that my research shared with them an interest in social communication and body-responsive aesthetics.

The material from the Context review that was of most help was the design philosophy of Dunne and the emotional characterizations of Norman. Their work enabled new thinking to be applied to the design practice. By considering garments as spaces for narrative interaction with the wearer (and the body via affective computing), the wearer becomes an active participant in the construction of identity and enters into dialogues with the garment and others. The expression and elicitation of paradoxical emotions, characteristics of anthropomorphism and personalisation were also proposed as aims for the practice, to enhance emotional impact with the wearer or viewer.

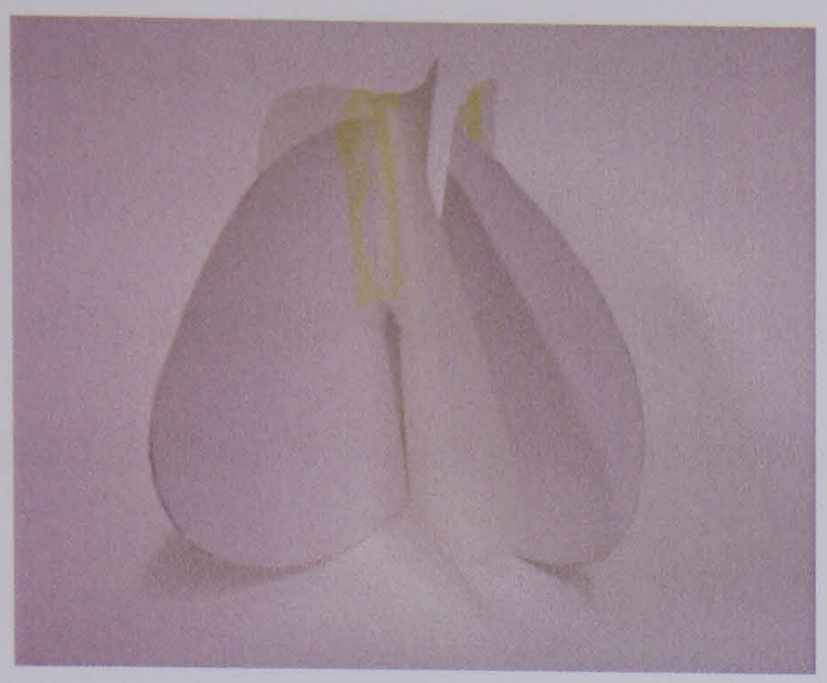
CHAPTER 3

Case Studies

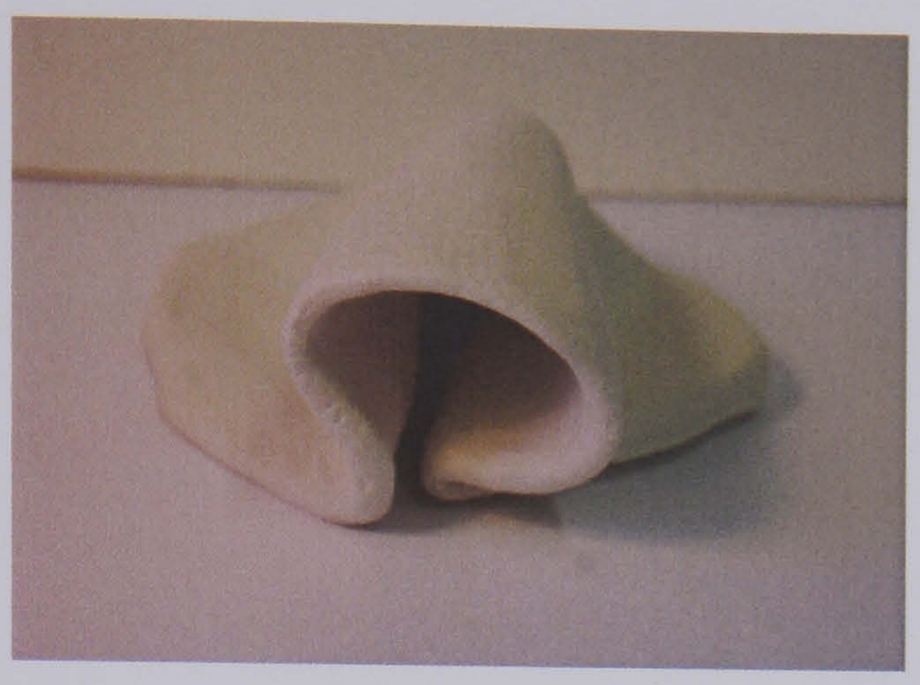
Planning The Case Studies

Taking my cue from other work in the field (Practice Review) and influenced by an emotional design context (Context Review), my practice set out to alter the definition of fashion communication by exploring responsive aesthetics that communicate and elicit contradictory emotions in the wearer or viewer. The marriage of fashion and technology was tested through a series of material experiments, each supporting the emotional narrative of the garments and investigating whether traditional fabrics and material technology can be successfully integrated together.

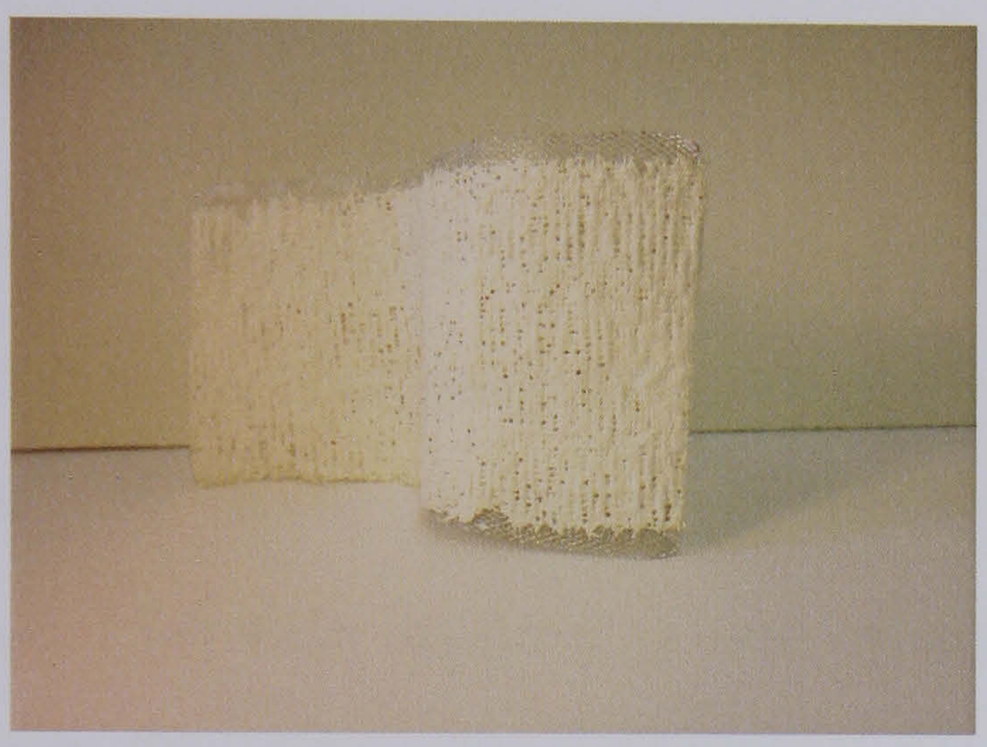
These experiments resulted in my 'case studies', three unworn and one worn garment. However, before I developed the finished garments I began with some earlier 'emotion' experiments. These were a series of fashion and design methods that kick-started the research. The methods employed were model-making, three-dimensional theme boards, modelling on the stand and toiles. For the first two, clay, paper and wire shapes were created which were subconscious responses to the emotions of joy, sadness, anger and calm (Fig.3. 1). These shapes were used as inspiration for two three-dimensional theme boards denoting sadness and happiness. Research into body language was represented in abstract terms as colour, shape and pattern. (Fig.3. 2). I then progressed to modelling on the stand and toiling. Toiling is a conversation with



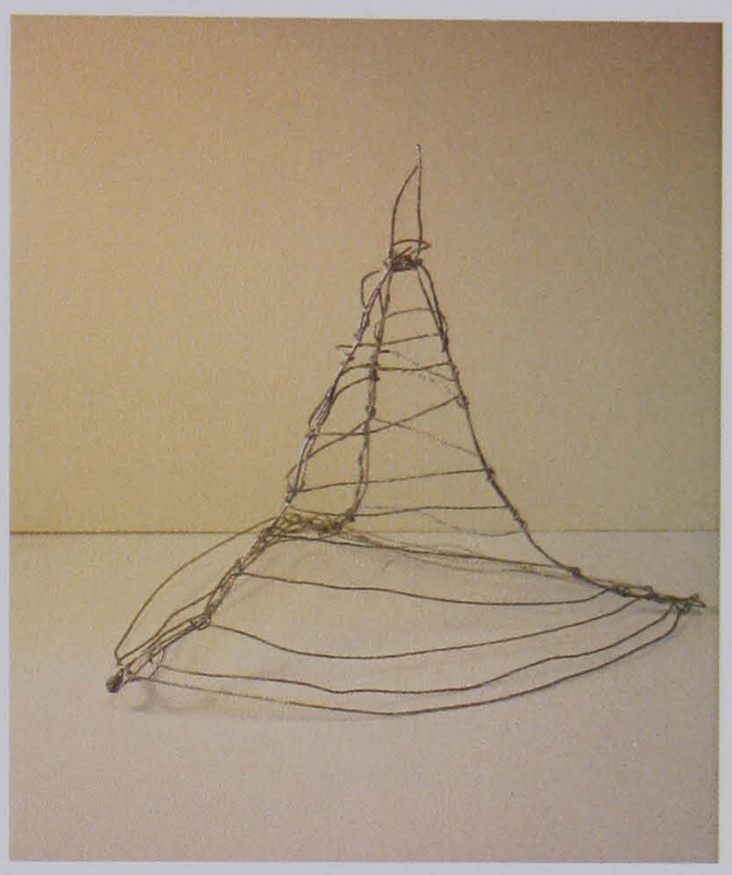
Joy



Sad



Calm



Anger

Fig. 3.1.
A series of models were constructed from clay, wire and paper as spontaneous expressions of emotion. The emotions visualized were joy, sad, calm and anger. Source: Lisa Stead.

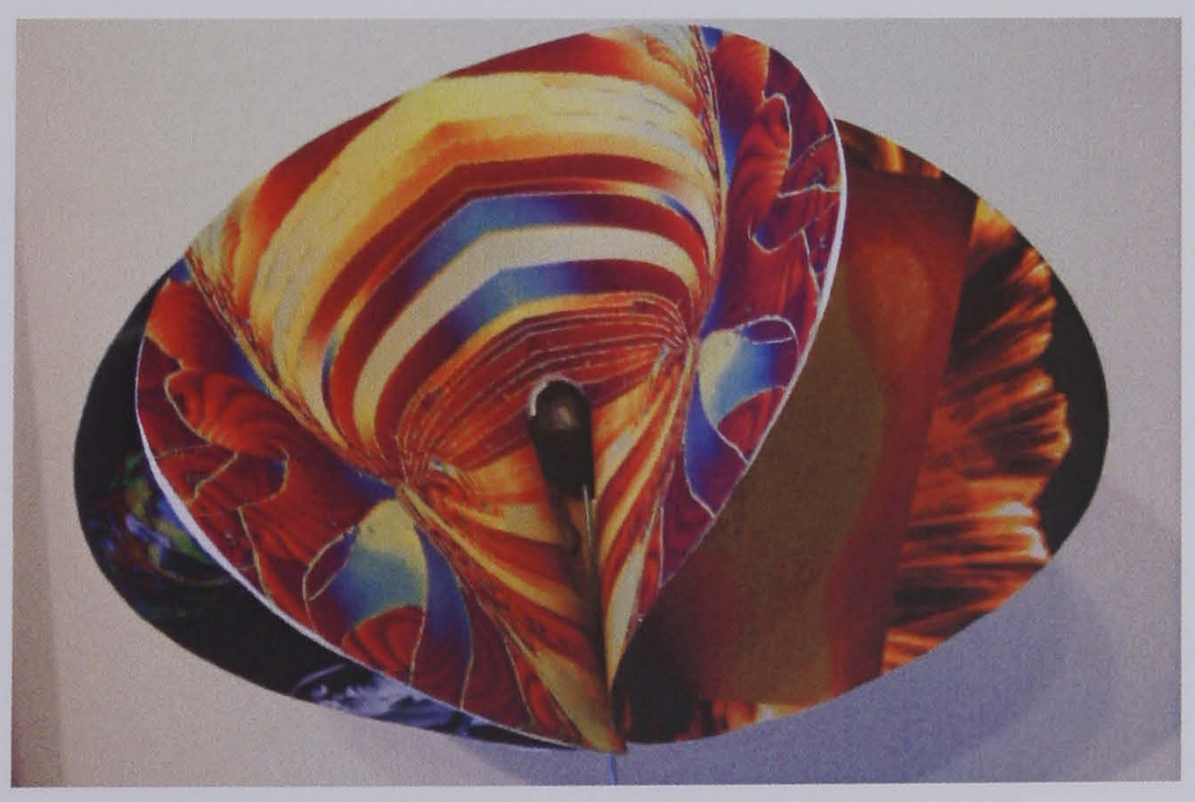


Fig.3. 2.
The 'joy' oval shape was translated into a three-dimensional theme board that illustrated characteristics of joy: movement, connection and glow. Source: Lisa Stead.

material, body, dimension and proportion and a successful toile usually provides a good fit on the body and a likeness to the intended design. I used toiles as three-dimensional outlines in the early emotion experiments. They were generated by pattern cutting and also by modelling on the stand which enabled my designs to emerge organically, rather than being predetermined.

Emotion Experiments

The emotion experiments functioned as a series of sketches to explore and observe the notion of emotional aesthetics. Each experiment addressed the communication of emotion - via shape, proportion and resemblance to aspects of associated body language. They were designed to work cumulatively, building on acquired ideas and knowledge. The experiments investigated the communication of emotion through the physicality of the garment toiles while drawing on research conducted into EL wire and EL polymer, a material which could provide a soft, switchable colour change effect if printed onto the surface of the garments. The printable nature of the polymer was a consideration during toiling and modelling on the stand and was remedied by creating continuous shapes with minimal seaming (Figs. 3. 3 –3. 8).

Fig. 3. 3. The Emotion Experiments – part 1

Emotion	Process	Outcome
JOY	The 'joy' shape followed the continuous oval shape of the theme board, which denoted movement, a characteristic associated with happiness. The shape used a slash from the outside edge to the centre, to allow it to be manipulated around the stand and to also be joined with a twin shape to extend its size if necessary. The shape was modelled in foam sheeting so that it would retain its shape whilst being manipulated on the stand to see what garment like shapes could be created. As each new shape was explored and pinned in place it was photographed as a document of the process. (Fig.3. 4)	The Joy oval was a simple shape that would not require seaming as it provided a continuous surface around the body. These properties would make the garment shape ideal for printing EL polymer, as it could be applied continuously without the interruption of seaming to create a changeable colour display. The most successful modelling was the simplest asymmetrical use of the oval to suggest a skirt. When this shape was turned upside down to create an upper body covering it also suggested a 'sad' shape. This might be due to similarities with mouth shapes when expressing joy or sadness. When observing the joyful skirt, the curve of the hem 'smiled' a playful quality, which is enhanced by the unbalanced proportions of the garment. In contrast the 'sad' top mirrored a downward mouth. As the garments were the reverse of each other, they could physically connect at the outside edge to create a continual wave or a passing of emotion from happy to sad (Fig.3. 5). This demonstrated that the use of human-like qualities, such as the 'smiling' hem, could be used in garments to enhance emotional communication and connection.
ANGER	Anger was modelled on the stand using calico. A three dimensional channel was incorporated within the garment so that EL wire could be used in one continuous piece to aid integration in the garment if required. The modelling borrowed the analogy of anger rising up the body towards the face, as found in body language. The toile was constructed by pinning the fabric to the stand to conform to the shape of the body. (Fig.3. 6)	The overall shape constricted the body reflecting a tightness of body and muscles during anger. It generated a movement of line around and up the torso, finishing at the face to emphasize building anger. This effect could be enhanced by the addition of EL wire to light up the body in a continuous movement. The light could exaggerate the garment shape and emphasize the movement of anger up the body resulting in a focus on the face. This garment toile suggested anger but it visualised a fixed emotional state and the garment would still look 'angry' when the emotion had passed. This highlighted the necessity of changeability in response to emotions which was addressed in the next phase of the experiments where a conscious decision was made to represent a change in emotions through garment physicality.
SAD SHROUD	The sad shroud looked to feelings of invisibility and isolation for inspiration. A tubular piece of jersey was draped on a model's torso to provide the shape for toile. The aim was to hide the face so the fabric was arranged until a suitable position was found. This shape was then remodelled on the stand in paper and dimension was added to the flat surface by slashing into the pattern and adding inserts to create fullness.The pattern was then remodelled in flat jersey. (Fig.3. 7)	The toile shape successfully hid the face and suggested sadness, mirroring a similar drooping shroud shape modelled in clay as a subconscious response to the emotion. Although the shape was first modelled in a tubular material this was later abandoned due to the difficulties of using a three dimensional fabric with EL polymer technology. The three dimensional shape was replaced by flat pattern cutting to provide a simple surface for printing. The toile proved that the same look of the tubular fabric could be generated by flat pattern pieces, which would aid the integration of technology.

Fig. 3. 4.
'Joy' was modelled on the stand using oval shapes constructed from foam. Each remodelling was an extension of last by placing emphasis on different parts of the body and by moving the shape around to explore its various dimensions and proportions in relationship with the body. Source: Lisa Stead.

Fig. 3. 5.
The discovery of a sad shape as a counterpoint to joy suggested a transferal of pattern from one garment to the other. The shapes could be linked together physically and by using a sensor to 'pass-on' on a happy pattern from the joy shape to the sad shape.
Source: Lisa Stead.

Fig. 3. 6
'Anger' was modelled on the stand. A channel was constructed to increase in height as it progressed up the body to mirror an increase in anger until it merges into the collar shape.
Source: Lisa Stead.

Fig. 3. 7.
The Sad Shroud modelled on the body in tubular jersey attempted to hide the face, constrict the body and express a slumped 'sad' aesthetic. It was then converted from a three-dimensional shape into a flat pattern piece and successfully translated into a three-dimensional shape derived from pattern cutting techniques.
Source: Lisa Stead.

Fig. 3. 8. The Emotion Experiments – part 2

Emotion	Process	Outcome
SAD/HAPPY CAPE	To approach the happy/ sad conflict from another perspective I returned to the 'joy' shape that could also become sad, in my initial modelling on the stand. This provided a suggestion of changeability. A continuous three dimensional oval shape was constructed in calico made from two ovals stitched together. The calico provided a soft interaction with the body as opposed to the supported oval shape which was modelled earlier in foam. Several different holes were slashed into the shape at the centre and towards the end of the oval to allow the body to wear the shape in different ways.	It was observed that the simplest use of the shape on the body was the most effective. I chose a cape to denote sadness, which could be draped over the head to create an isolated space for the body (Fig.3. 9.) Happy was illustrated by a simple full 'oval' as opposed to 'circle' skirt, to show movement. The oval of the skirt shape creates a movement in the falling folds of the outside edge whether or not the skirt was moving on the body of the wearer (Fig. 3. 10.). The use of simple shapes on the body could be paralleled with the work of Miyake, in his 'Making Things' exhibition. In these garments Miyake explores shape and space on the body. My application uses shape to aid material technology integration and the expression of emotion. Interaction with the wearer is used to create a simple process of customisation via the garment rather than the technology This experiment addressed the integration of technology from a construction perspective by reducing the garment to the intersection of two simple shapes. This method could allow EL polymer to be placement printed without the interruption of seaming. Other simple shapes, such as oblongs or squares could be explored to construct a garment and to simplify the integration of technology.
SAD/HAPPY FRAGMENTS	To address the issue of interaction and changeability, sadness was approached from the perspective of stagnation, as a lack of movement or slow movements express sadness. This was developed into the concept of restriction and the binding of the body in material fragments. By attaching strips of fabric to the model I was able to both constrain her movements and hide her body and face to indicate invisibility. The strips were placed, evaluated and replaced until a suitable level of constriction was reached. The strips were positioned to correspond with body movement and limbs. Therefore the areas of the arms and legs were targeted to maximize constriction (Fig.3. 11.) The manipulation of the strips around the body also provided a way to show movement or happiness. Once the strips were unwrapped from the body they created movement 'markers' to emphasize the body in movement, expressing joy (Fig.3. 12.)	The fragmented approach was a successful tool to think about the body, emotion and motion as it provided a physical barrier to movement and a low-tech approach to interaction with the wearer. It also provided another way to address the integration of technology. The transformation from sad to happy state could be enhanced by the application of a light technology as a light 'therapy' (Fig.3. 13). Interaction could be enhanced further by the addition of an 'attach and release' system for the garment strips, which would also be used to customise the garment. If developed this approach could provide the basis for a modular system of garment construction. The movement of the body in the happy state would also have to be considered as an additional stress on the connection device.

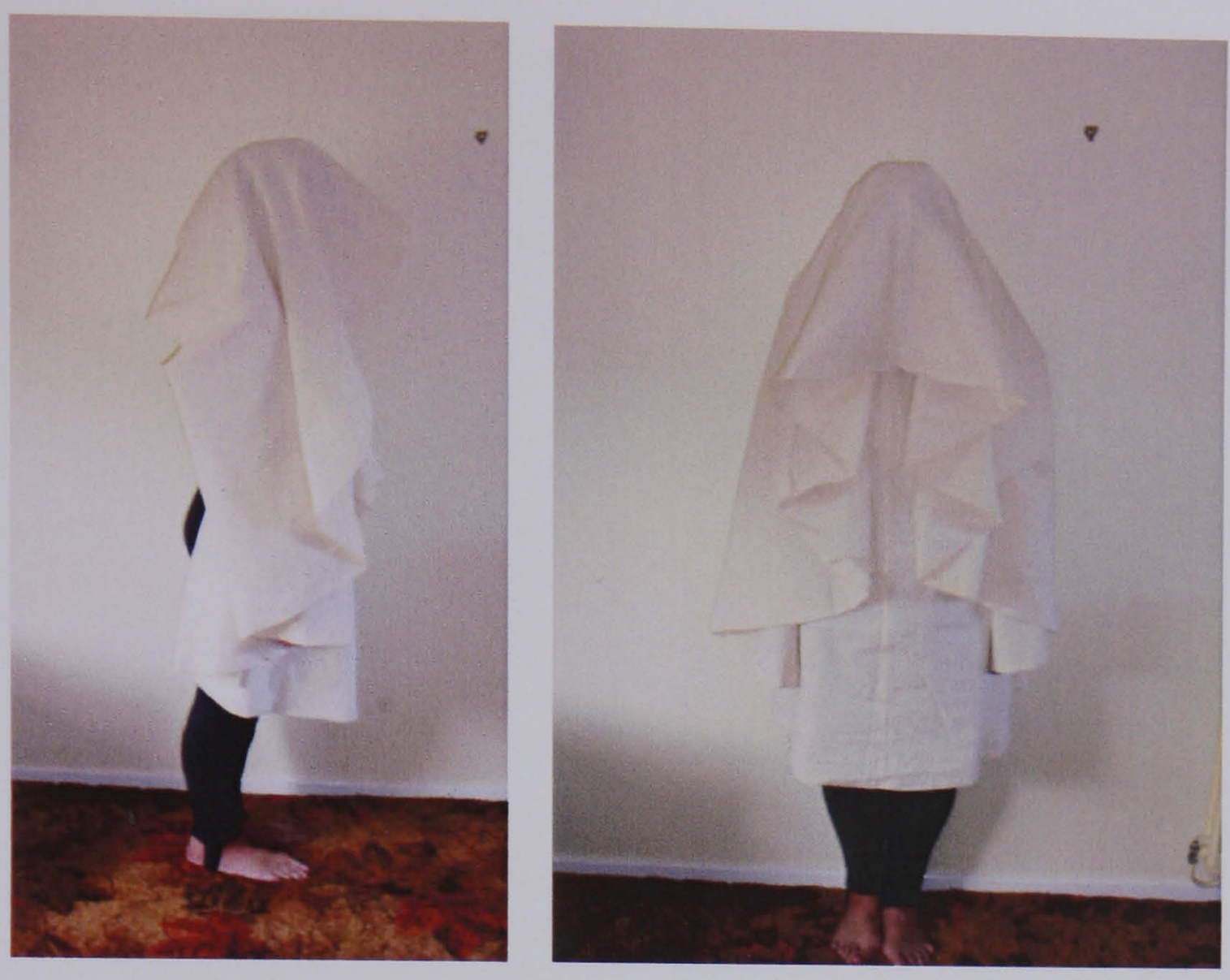


Fig. 3. 9.
'Sad' was denoted as a head covering using three-dimensional oval shapes constructed from calico. EL polymer could be used inside the cape hood to provide light therapy around the face, the coloured glow matching the desired emotional outcome whether to stimulate or calm the wearer.
Source: Lisa Stead

Fig. 3. 10.
Happiness was communicated via a full-oval skirt that suggested movement whether the wearer was moving or not. Printing a moving graphic in EL polymer could also enhance the movement of the skirt across the surface of the garment. It was my intention that the garment could transform from sad to happy by pulling the oval down from the shoulders to the waist creating an interactive garment. Source: Lisa Stead.

Fig. 3. 11.
Sad/ happy fragments. Placement of the strips was evaluated by their impact on movement of the body and their overall effect on body coverage. The aim was to balance the two elements.
Source: Lisa Stead

Fig. 3. 12.
Consideration of the unwrapped aesthetic also determined the placement of the strips in the sad/happy fragment experiment. The experiment therefore became a balancing task between the aesthetic as wrapped and unwrapped on the body.
Source: Lisa Stead

Fig. 3. 13.
El polymer could be printed onto the garment fragments. In the closed, 'sad' state, therapeutic light could glow on the strip that covers the face. When the strips are released to aid movement, the light could sparkle on all strips. The activation of the strips could be determined by the level of movement detected by motion detectors in the modules. This aesthetic would be used to heighten the communication of joy.
Source: Lisa Stead

The emotion experiments fed into the case studies, providing both a model of how to communicate emotion and a basis of garment construction techniques that incorporated material technology. It was through the investigation of these experiments, via emotional shape models and toiles, that the model of body language as abstract shape and low-tech interaction was developed. This model was expanded to include the use of body language postures and traits to communicate human as well as emotional information in the Unworn case studies and as a device to understand the use of the body in expressing emotions in Emovere. Body language information is also used in Emovere to provide appropriate zones for the placement and sequencing of the lights in the garment.

Having started with the emotional experiments I then moved on to develop the case studies. They comprise: Pik Me, a scarf; Desiree, a dress, and Icaris, a jacket, which operate as installation pieces, and one garment, Emovere that is wearable. The Unworn garments integrate material and electronic technology with more traditional fabrics to explore changeable aesthetics. Emovere expands the concept of a variable display, by extending responsive technology with affective computing. In this way it creates responsive and programmable aesthetics that react to changes in the body.

The case studies function in different ways. They act as single case studies for an investigation of a different material and electronic or computational technology. As a multiple case study, the Unworn garments form a progressive model of technological integration, understanding and application. Considered together, the case studies show a shift in emphasis from reactive to personalized 'emotional' displays to aid fashion communication.

They are therefore, simultaneously exploratory, descriptive and explanatory tools. They explore the technical information that has been gathered and subjectively evaluated against the contextual framework governed by the theories and issues that have arisen from the Context Review. They also describe the process of inquiry and seek to explain the phenomenon that has occurred through the process of making and reflection the PowerPoint Presentations CD contain a timeline of the case study process.

Unworn Garments

Context

The Unworn garments looked to solitary living and the domestic environment in the twenty first Century for narrative inspiration. If we are living and working in isolation at home, should the things around us provide richer emotional interactions and can technology be used to facilitate these exchanges? To define what form these 'emotional interactions' should take, I researched solitude from opposite perspectives. On the positive side, solitude in the home can facilitate self-reflection and a space for the imagination to flourish and grow. As Gaston Bachelard notes, ' the house shelters daydreaming, the house protects the dreamer, the house allows one to dream in peace.'[174] However, solitude can also create feelings of isolation which are played out in patterns of body language and behaviour, as Fast observed of a woman living alone 'picking up a small alabaster paperweight...running one hand along the velvet of the couch, then feeling the wooden carving...She was telling them in body language, "I am lonely. I am starved of companionship. Help me!'[175] The fact that objects around the house can be imbued with emotional content recalls the ideas of emotional design. The idea of approaching garments as objects, and the concept of clothing characters was suggested by an article by Saulo B. Cwerner in which he describes the wardrobe as a 'classification of identities'.[176] From this research the concept of the Unworn garments were developed.

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[174] Gaston Bachelard, *The Poetics of Space*, (Boston: Beacon Press, 1994) p.6. This positive view of the home can be contrasted with 'Home' by Megan Terry, a play that defines a fictional view of the future where we all live in isolated family pods due to a massive population explosion as mentioned in Julius Fast, ' Body Language', (England: Pan Books, 1972), pp.25-26.

[175] Julius Fast, p.17.

[176] Saulo B. Cwerner, 'Clothes at Rest: Elements for a Sociology of the Wardrobe', *Fashion Theory*, 5, (2001) pp.79-92. It is Cwerner's intention to challenge the traditional emphasis in fashion theory which views clothing as being on the body and 'in movement' by looking at 'wardrobe practices'.

Objectives

The objectives of the Unworn garments were:

- To give an inanimate object human traits and emotions
- To communicate these emotions to a viewer
- To integrate responsive material technology with traditional fashion fabrics

Narrative

The Unworn garments 'live' around the house. They are experiments in the merger of clothing and technology for aesthetic and emotional purpose. They suggest that clothing which is left unworn could assume a new emotive function by reacting to human presence. By representing human characteristics, fears and fantasies, they seek to provoke paradoxical emotions in the viewer. They led me to ask whether expressive and responsive qualities in clothing would enrich our emotional connection to garments or prove uncomfortable and disturbing?

Garment Development

The process of Unworn garment development was as follows; narrative construction, selection of suitable technology to match garment 'character', material technology understanding derived by working with or against its inherent properties, integration of the technology to provide a tactile aesthetic, which expresses the emotional narrative of the garment and finally the programming of the technology to further enhance the emotional aesthetic display. The character narratives for the Unworn garments were informed initially by photographs of garments around the house which were used to develop the idea that each garment had a personality, an emotion to express and a

place to be situated within the home. Emotion and character were determined by the appearance and 'pose' and emotional body language of each garment. The character outlines were expanded by looking at other contemporary designers of objects and clothing and contextual research into themes such as self-harm, myth and attraction.

Pik Me

Narrative

Pikme is a scarf that hangs on a coat stand by the front door. She feels distressed and lonely. As you prepare to leave the house, she gradually reveals more of her pain to you, linking proximity with intimacy. She craves the comfort of human touch and the warmth of a neck, so 'pick' her!

The Pik Me narrative was inspired by a slouchy knitted cardigan, a ripped and torn jacket lining and a ragged scarf, which evoked a sad, fragile and lonely character (Fig.3. 14). The emotional tone and ripped aesthetic of the clothing suggested the conditions of depression and self-harm. As these garments hung on the back of a door, Pik Me was hung on a coat stand from where it could act as a vantage point for the garment to 'cry out' for attention when the owner was leaving the house.

Influence

The desire to express issues of depression and self-harm through textile manipulation and garment form was a driving force for the ideas and implementation of Pik Me.[177] Self-harm functions as a control mechanism and a way of expressing repressed emotions when it 'translates invisible internal damage into visible external damage'.[178] The most common form of self-harm is cutting, followed by inflicting blows to the body, thereby causing extreme bruising.[179] A scarf seemed an apt garment for communicating this desperate condition, as the neck unites the body and the brain, emphasizing the connection between the psychological condition and its physical manifestation on the body.[180] Gitta Gschwendtner's *Strangled Lights* (Fig.3. 15), provided a model for the scarf by showing how an inanimate object could be made to visualise human suffering. Depression is signalled by a lowered head and slumped body posture, and Gschwendtner's lights are drooping from their lead, hung literally from the ceiling. Another influence was the textile artist Jacy Wall's piece, *Holding Together* (Fig.3. 16), which uses traditional weaving techniques to distress the fabric.[181] It appears frayed, damaged and slashed and she uses red silk to back the pale hanging so that, when hung on a window, the slashes resemble bleeding cuts. The work of these designers provided visual tools to communicate intense and personal experiences, a process Deborah Padfield explains as translating unconscious

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[177] Although the expression of such subject matter through textiles/ garments could be seen to trivialise unspeakable pain, a precedent for the communication of pain through aesthetics can be seen in the research of Deborah Padfield. She worked with patients to create visualisations and photographs of their experiences of self-harm and illness, both physical and emotional. Far from making light of the issues she says that the distance from the subject matter that the photographs afford the viewer or the patient can be beneficial, 'allowing us to look at aspects of ourselves, and experiences, which have hitherto been too painful to acknowledge.' See, Deborah Padfield, *Perceptions of Pain*, (UK: Dewi Lewis Publishing, 2003) p.21.

[178] Maggie Turp, *Narratives from Psychotherapy*, (London: Jessica Kingsley Publishers, 2003), p.188

[179] Maggie Turp, p.80

[180] Desmond Morris, *Bodywatching: A Field Guide to The Human Species*, (London: Jonathan Cape, 1985), p.177

[181] The textile piece was viewed at 'Footsteps', an exhibition at Walford Mill Craft Centre, Wimbourne, Dorset on 18 June 2004

Fig.3. 14.
Pik Me was inspired by photographs of an old, slumped cardigan 'sitting' in a chair, a frayed scarf and a weathered leather jacket with a torn lining.
Source: Lisa Stead.

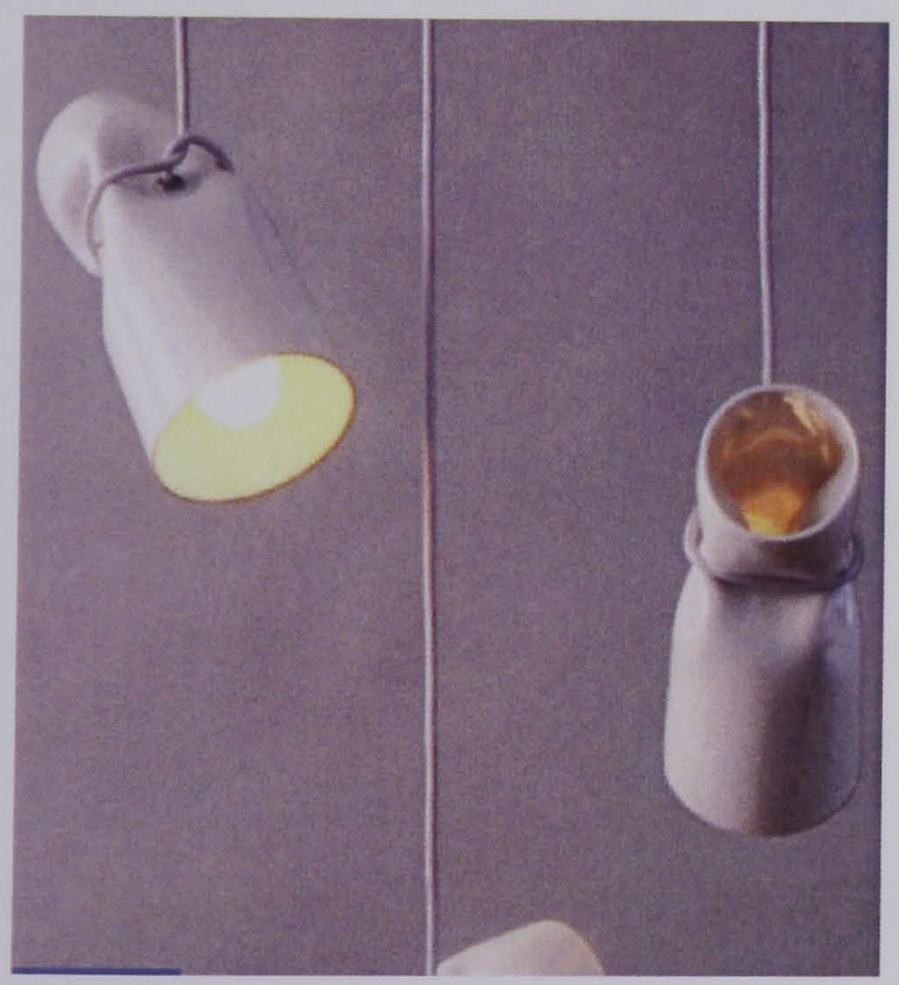

Fig.3. 15.
Gitta Gschwendtner, *Strangled Lights*, A model for giving inanimate objects life by anthropomorphic tendencies.
Source: *Icon* September (2005)

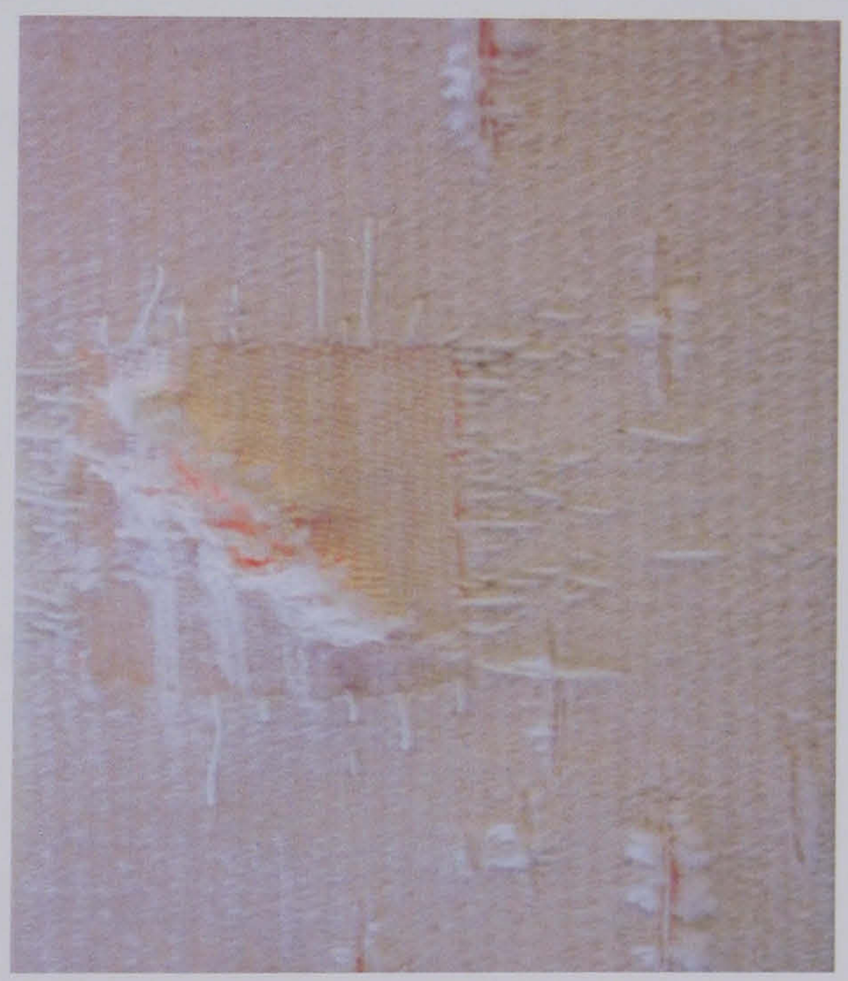

Fig.3. 16.
Jacy Wall's, *Holding Together* , uses traditional weaving techniques to communicate human suffering by making reference to cuts and 'mending'.
Source: Lisa Stead.

aspects of human existence into 'objective, "readable" object[s]'.[182] The issues were assembled to provide a garment outline of a scarf, which self-harms to express its pain and loneliness. The lighting technology was intended to show the stages of harm, first showing the pulsing vein, then the bruised body and finally the cut wrists. It was the intension of the research to communicate visually the effects of harming behaviour through the use of textiles and technology.

Technology And Why Chosen

EL wire was chosen for the scarf to compliment its elongated shape. The linear quality of the EL wire suggested knitting or weaving as a construction process as if the wire were a yarn, which also fits with the nature of a traditional scarf. In addition, the EL wire has a moldable quality, which allows the scarf to be manipulated into contorted shapes. The wire is also available in a range of colours and thickness enabling experimentation. The only drawback with EL wire is the necessity to incorporate power inverters and a main power source which preclude the scarf from becoming wearable if necessary.

Objectives Of Pik Me

- To make an unworn garment represent sadness and evoke empathy and disgust.
- To integrate electroluminescent wire into a fabric.
- To make the technological intervention still look like a wearable garment.

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[182] Deborah Padfield, p.21.

Method Selected

The method selected was to work with and against the material technology to understand its properties. This knowledge then informed the material use in the garment.

Technology Support

Ben Sheehan, an independent electronics and computing consultant was employed to provide the technical support for the EL wire and sequencing.

Material Experiments

To understand the properties of the EL wire, a series of material experiments were conducted. The wire was woven, knitted and encased in yarn to assess its pliability and external aesthetic qualities (Fig.3. 17). The wire was found to have a good level of flexibility, while retaining its ability to glow but its plastic covering and bulky appearance provided a undesirable aesthetic. To counteract this problem the focus of the experiments was switched to the selection of a covering fabric, which could provide a housing for the wire, which would be used as a linear light source to reduce bulk.

At first silk twill and chiffon were layered, padded and manipulated to represent bruises, cuts and veins (Fig.3.18). The overall effect was overworked and unrecognizable as belonging to part of a scarf. The original idea of the knitted scarf as photographed in the domestic environment re-emerged as new knit samples were produced to represent veins, three-dimensional bruises and slits. A traditional cable and rib stitch provided a garment vein and a buttonhole stitch with fringing created a slash in the

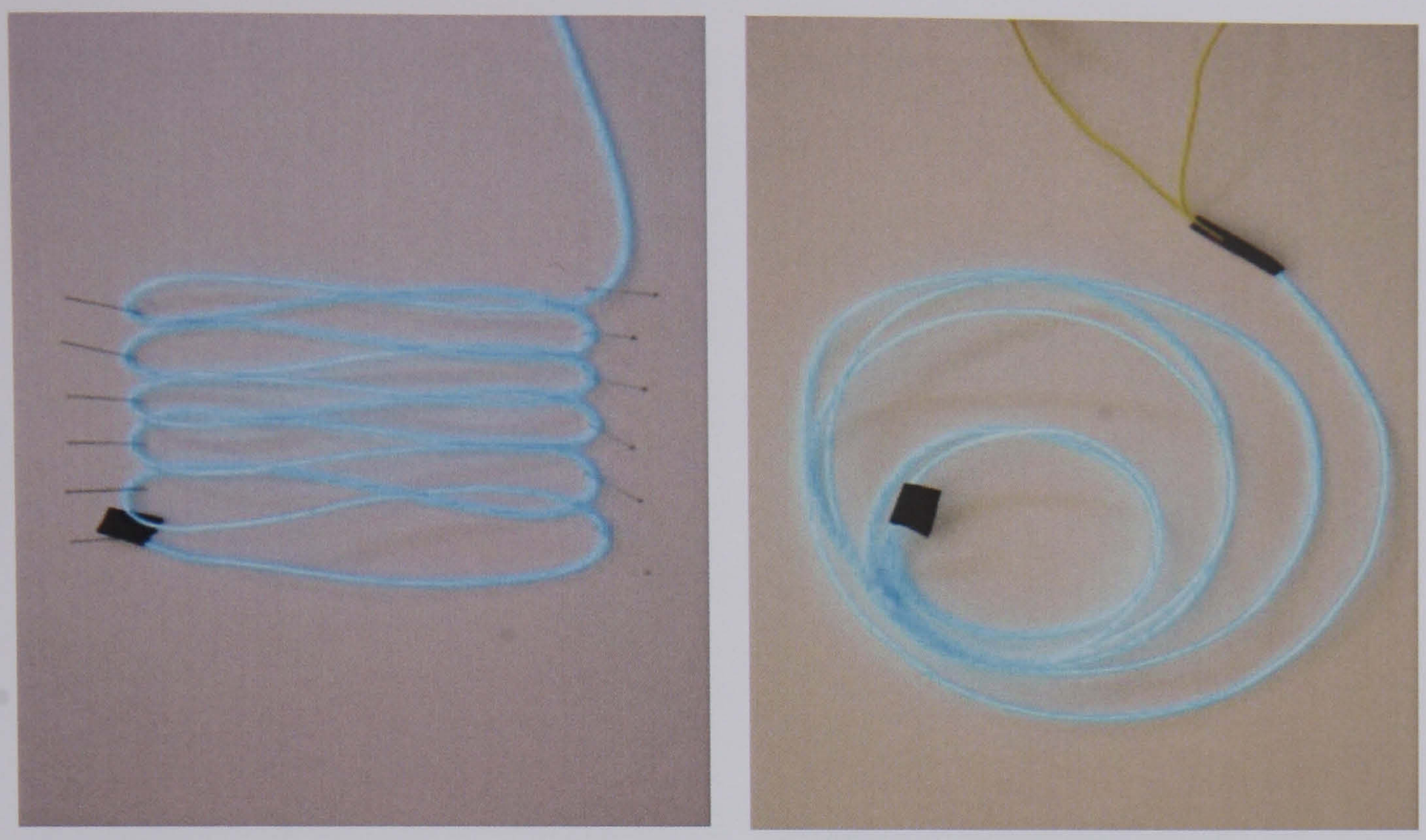

Fig.3. 17.
EL wire was woven to assess its flexibility. Although the wire proved to be supple as a single thread, layers of woven wire created a very firm material.
Source: Lisa Stead.

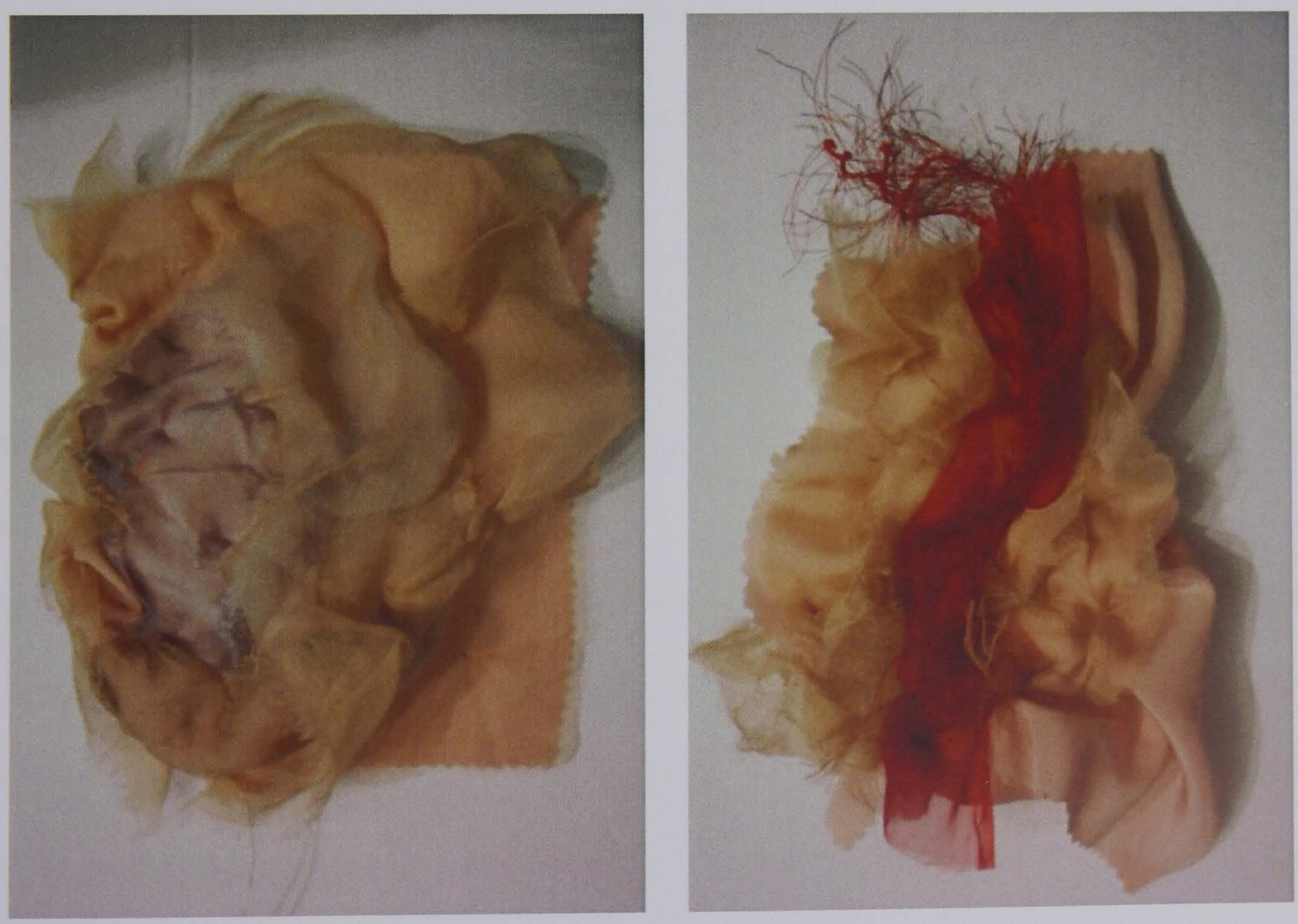

Fig.3. 18.
Layers of silk chiffon and padding were stitched together to represent cuts, veins and bruises but this combination looked more like textile art than a wearable garment.
Source: Lisa Stead.

Fig.3. 19.
A traditional cable knit stitch was used to create a vein-like channel in the fabric. Buttonhole stitch was used to produce slashes in the knit which would allow light to seep from inside the scarf.
Source: Lisa Stead.

body of the knit (Fig.3. 19). A knit pattern was designed to place the slashes in random positions at either end of the scarf to ensure that the display would be viewed clearly when the scarf was hung on the coat stand.

To integrate the wire into the knit pattern, one length of blue EL wire was woven behind the knit rib stitches to provide colour and movement for the garment veins. A second length of aqua wire was created that mixed active EL segments with plain sections of wire. This allowed the glowing segments of the wire to be placed in small areas around the scarf rather than the wire glowing throughout its length. The wire was coiled to represent a bruise which was laid immediately behind the knit surface. The third, red wire was constructed in a similar fashion and stitched around the opening of the

slashes. The mouldable nature of the wire provided added dimension to the scarf openings. To represent a gradual need for attention the electroluminescent wire was divided into 3 timed circuits, in 3 colours, each connected to its own inverter to provide current and the individual pattern of the sequence.

The blue wire was triggered first by viewer presence using a proximity sensor. This colour was programmed to glow in a pulsing rhythm to signify the pulsing of the vein. Next the aqua wire was activated as a constant glow. Finally, the red wire was triggered to create a continual 'bloody' glow through slashes in the knit, to represent self harm and the cutting of the arteries (Fig. 20.a & b. See also Unworn and Emovere Films CD to see the scarf in motion).

Fig. .3. 20.a.
A detail from Pik Me (2004) shown as an installation at my PhD exhibition held at Central Saint Martins College of Art and Design in London. Source: Claire Robertson

Fig. .3. 20.b.
Pik Me (2004) shown as an installation at my PhD exhibition held at Central Saint Martins College of Art and Design in London.
Source: Claire Robertson

Revision

Initially, I presumed that I would weave or knit the EL wire but this proved bulky and revealed the sterile quality of the wire. Wrapping of the wire in yarn also proved unsuccessful as it was too bulky. Deciding to conceal the wire behind the knitting rather than knit with it provided the solution.

The other main revision that occurred within the process of development was the choice of knitted wool rather than fabric for the scarf. Experiments with chiffon and silk as the fabric overlay to the lighting resulted in a 'textile art' aesthetic, which looked unwearable and unlike a traditional scarf. The decision to use a knitted wool casing provided the scarf with a reconisable 'scarf' identity and a means to obscure the bulk of the wire.

Evaluation

Pik Me met some of its objectives as I felt its sad personality translated successfully into a slumped, slashed and distressed scarf. The decision to use traditional knitting meant that the garment looked wearable and the concealed light sequencing provided a visual display. The technology allowed me to experiment with building narrative tension through a change in pattern and colour. However the integration of the EL wire was not terribly successful as the wire retained its linear quality when lit, which separated it visually from the main body of the knit garment. This made the communication of the character less successful as the technology and the garment were not fully integrated. A mix of lighting technology might have provided a more integrated aesthetic. The EL wire could still be used for the pulsing veins but LEDs could provide a better source of generalized glow for the 'bruise' and 'cut' sections of

the scarf. Furthermore to guarantee the successful integration of a linear lighting system within a garment, the lighting would need to become tactile. A fibre that retained its soft and pliable qualities but possessed the ability to contain a controllable light source would provide a possible solution. The development of electrochromic polymers in the future might fulfil this purpose.

An alternative approach would be first to work with and against the intrinsic properties of the material and then to assign it a human character. This would enable the garment to fit the material rather than trying to fit the material to the garment character. This would place the material exploration at the beginning of the development process and might produce a different focus.

Desiree

Narrative

Desiree uses electroluminescent 'sequins' which are mixed with traditional textiles to 'flirt' with the viewer. She is sexy and provocative. When she senses your presence she shimmers, her signals becoming more excited as you draw nearer, imitating the human gaze during the ritual of flirting. She is the dress that you wish to wear but is now too small. She teases you as you contemplate your reflection in the mirror.

A white sequined top that shimmered amongst the surrounding black clothes in the wardrobe inspired the narrative for Desiree (Fig.3. 21). As the sequins caught the light, the top glistened. It seemed to express a flirting quality and a willingness to be desired

and worn. To bring detail to the narrative, the body language and rituals of flirting were assessed to see if I could give Desiree greater powers of attraction.

Fig.3. 21.
A white sequined top that shimmered from inside my wardrobe inspired Desiree. It was very noticeable against a group of black garments hanging beside it.
Source: Lisa Stead.

Influence

Attraction can be enhanced by a distinctive hip to waist ratio in women[183], a low décolletage and by wearing clothing that contains bold lines and accessories that

[183] Desmond Morris, *Bodywatching*, p 190

gleam.[184] Close proximity is also associated with successful flirting as it indicates permission to enter the personal body space of another.[185] Glances back and forth and an increased blink rate are also arousal indicators in the ritual of flirting.[186] Desiree's personality was to contain all of these elements, which would be projected through the use of material technology and program sequencing.

Technology And Why Chosen

To replicate the shimmer of the original sequinned top EL panels were chosen as they provide a flat and flexible light that can be programmed to glimmer and flash to attract the attention of the viewer. The drawback with EL is the necessity of an inverter box which can be cumbersome. Also EL panels have a limited colour range but this was not considered to be problematic as the original sequinned top was white.

Objectives Of Desiree

- To make an unworn garment that represents desire and evokes attraction and revulsion.
- To integrate EL panels into a garment.
- To make the technological intervention still look like a wearable garment.
- To understand the technological requirements for EL, from the beginning to the end of the process.

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[184] David. B. Givens, 'Love Signals', *The Nonverbal Dictionary of Gestures, Signs and Body Language Cues*, (2003), < http://members.aol.com/nonverbal2/lovesig1.htm > [accessed 26 December, 2003]
[185] Desmond Morris, *Manwatching: A Field Guide to Human Behaviour*, (London: Grafton, 1978), p 247

Method Selected

The method selected was to work with Elumin8 an EL manufacturer to gain understanding of the material and its construction process and to use this knowledge to inform the material use and integration within the garment.

Technology Support

Elumin8 provided technical information for the construction and programming of the EL panels.

Material Experiments

To understand the properties of the EL panels, I learnt how to cut, cover and solder the panels in a parallel circuit[187] (Fig.3. 22). A parallel circuit was used to ensure the brightness of the panels. By wiring the lamps in parallel, two wires for every lamp have to be accommodated within the garment. This is a major consideration when integrating the lamps within the dress. To solve this problem I sketched various ways of using body contouring to emphasize the overly sexy shape of the dress but also to use the seaming to accommodate the lamp wiring (Fig.3. 23). Ideas for seaming and integration were toiled in calico to assess suitability (Fig.24). A simple design with horizontal panelling was selected to emphasize the curves of the silhouette and to direct the wiring in the most immediate way to its desired location (Fig. 25). The wiring

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[186] Desmond Morris, *Manwatching*,p 71

[187] A parallel circuit is constructed by joining the positive and negative connector wires together before they are input into a power source or in this case an inverter. This creates one loop or circuit of wires for each lamp used and increases the amount of wires to be integrated within the garment. This is in contrast to a simple circuit where the positive and negative connectors are joined from one lamp to another, effectively creating one continual loop.

is routed along the dress seaming across the body and down the back to the inverter at the hem of the dress.

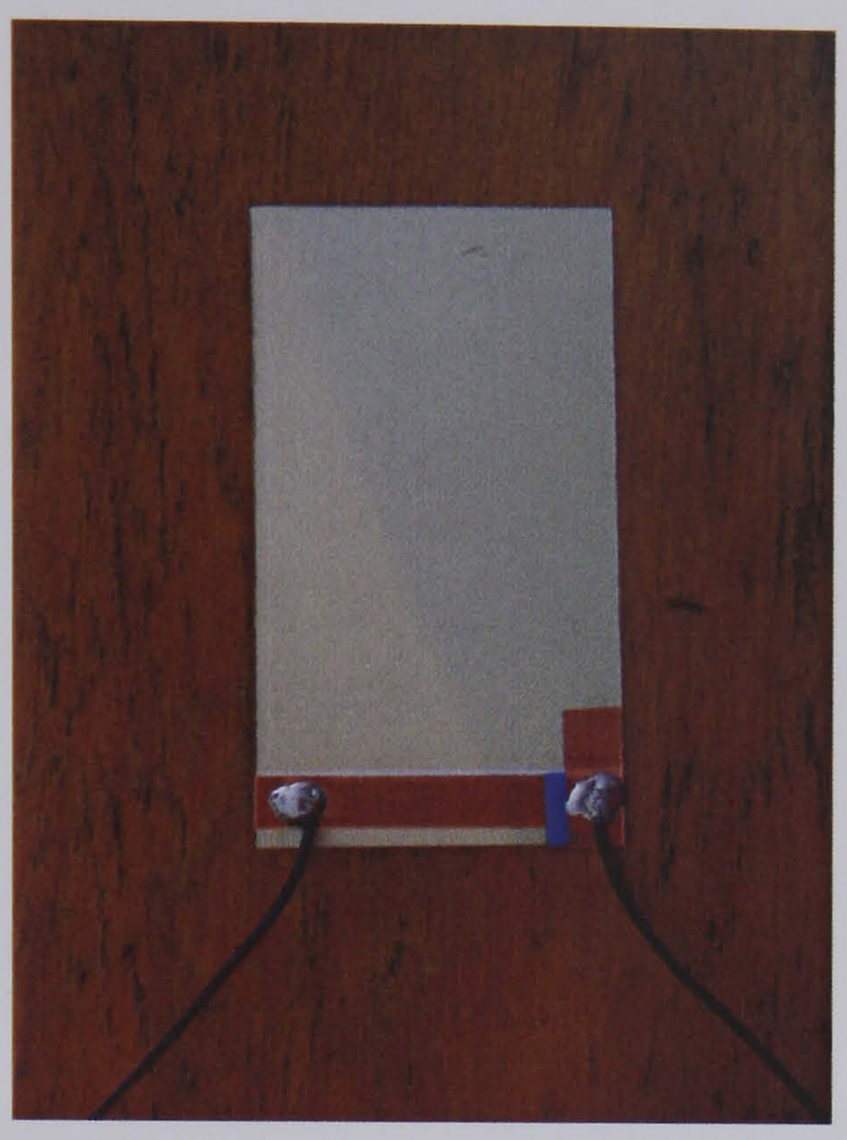

Fig.3. 22.
A parallel circuit was used to produce Desiree to ensure that enough power reached each EL panel.
Source: Lisa Stead.

Fig.3. 23.
Sketches of body contours and seaming were produced. They were considered as a decorative device to emphasize the shape of the body and as an aid to the integration of wiring.
Source: Lisa Stead.

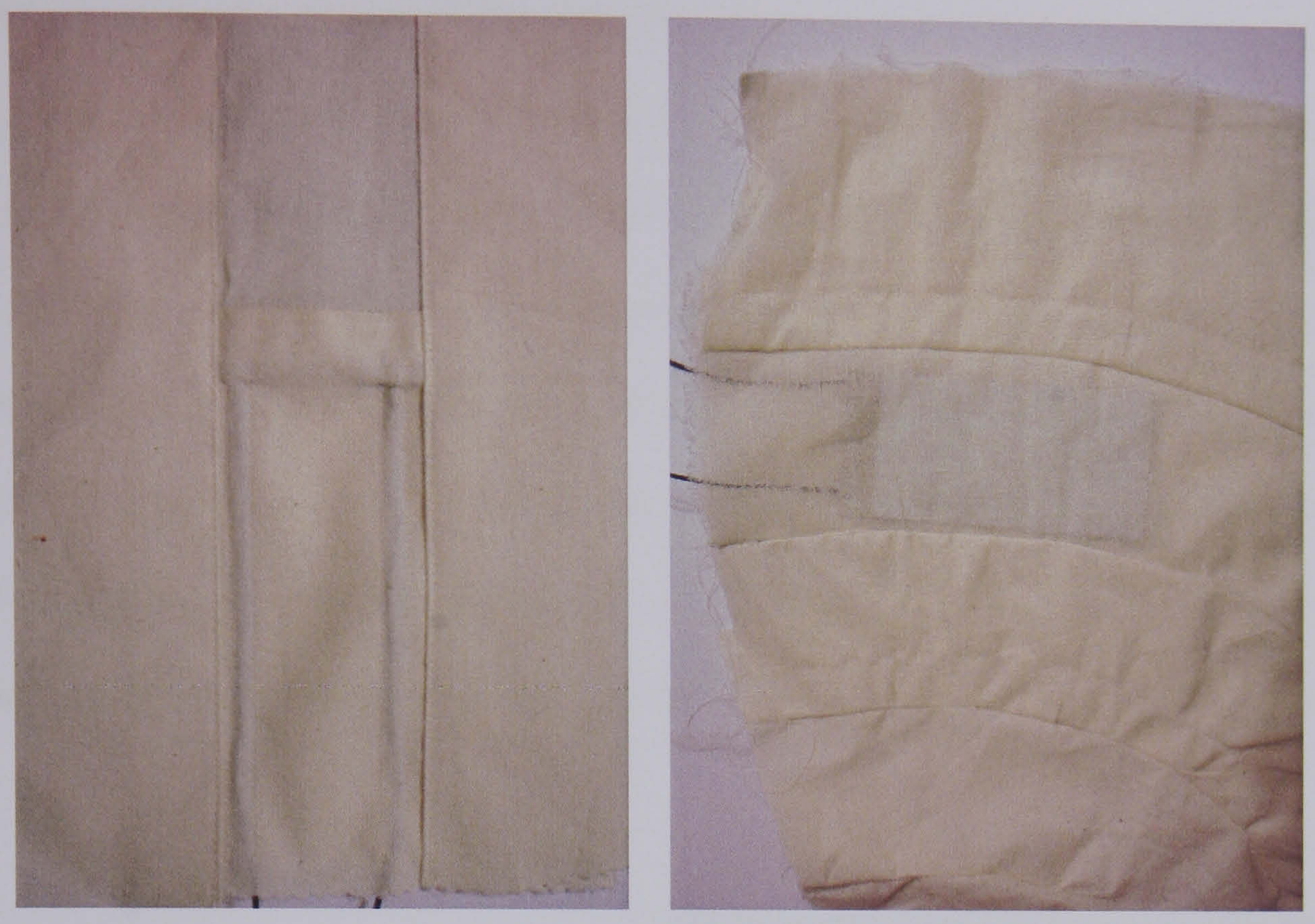

Fig.3. 24.
Swatches of seaming ideas were toiled in calico. They were tests for various ways of housing the EL panels and its wiring within the garment.
Source: Lisa Stead.

Fig.3. 25. Toiles were used to generate the shape and the position of the seaming for the final design of Desiree.
Source: Lisa Stead.

EL panels glow in either an aqua or a pink tone. To diffuse and change the colour of the light I conducted a series of experiments with various sheer fabric in a selection of colours. The experiments were inspired by *Caveman*, a light by Georg Baldere, in which he uses a simple device, the layering of tape, to change the colour of the light (Fig.3. 26). To assess the display possibilities and trial the garment seaming, I produced a toile in white velvet with coloured inserts (Fig. 3. 27). This proved that I could comfortably house the panels within the seaming system and change the colour of the light glow using fabric overlays. However the white velvet was considered an unsophisticated choice and was replaced with a richer and brighter colour palette.

Fig.3. 26.
Georg Baldere's, *Caveman* light (2000), inspired fabric experiments that were designed to both cover the EL panels and change the colour of their light.
Source: Lisa Stead.

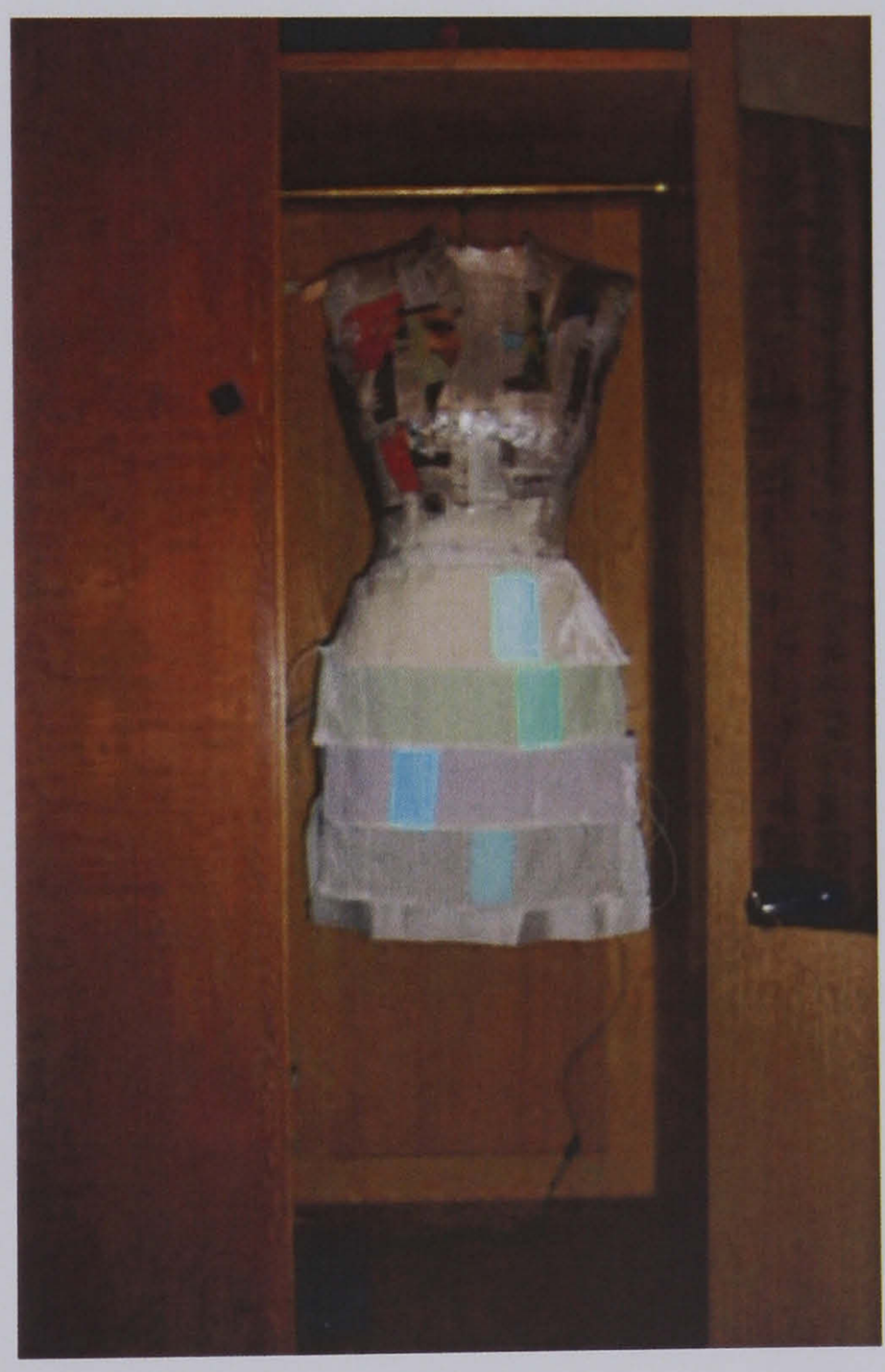

Fig.3. 27.
A toile in white velvet was produced to test the effectiveness of the chosen seaming and colour change design.
Source: Lisa Stead.

The program for the dress was based on eye gaze during flirting. It is triggered by proximity and is designed to flicker gradually up the body, increasing in intensity and urgency, until the dress blinks furiously in an attempt to increase the viewer's blink rate as a sign of attraction (Fig.3. 28. See also Unworn and Emovere Films CD to see Desiree in motion).

Revision

Initially I speculated that the EL could be used uncovered, cut into plastic sequins. However, the colouring and nature of the EL panels was very evident, and the constraints caused by wiring the panels in parallel meant that the clinical nature of the EL panel and the mass of wiring needed to be covered. As always the problems of material integration were paramount.

Evaluation

Desiree works as an exploration into the integration of material technology. It also acts as a document of my learning process and understanding of the technical issues for fabricating EL panels. However, I am less convinced that it works as a representation of a wearable garment.

The colours and shape of the garment are not as subtle as I would have liked. There have been areas of compromise in the design of the dress to accommodate the technology. Although the panels of the dress work well as a housing device for the EL, they appear bulky once the EL is inside. The fabric colour is garish in daylight but the

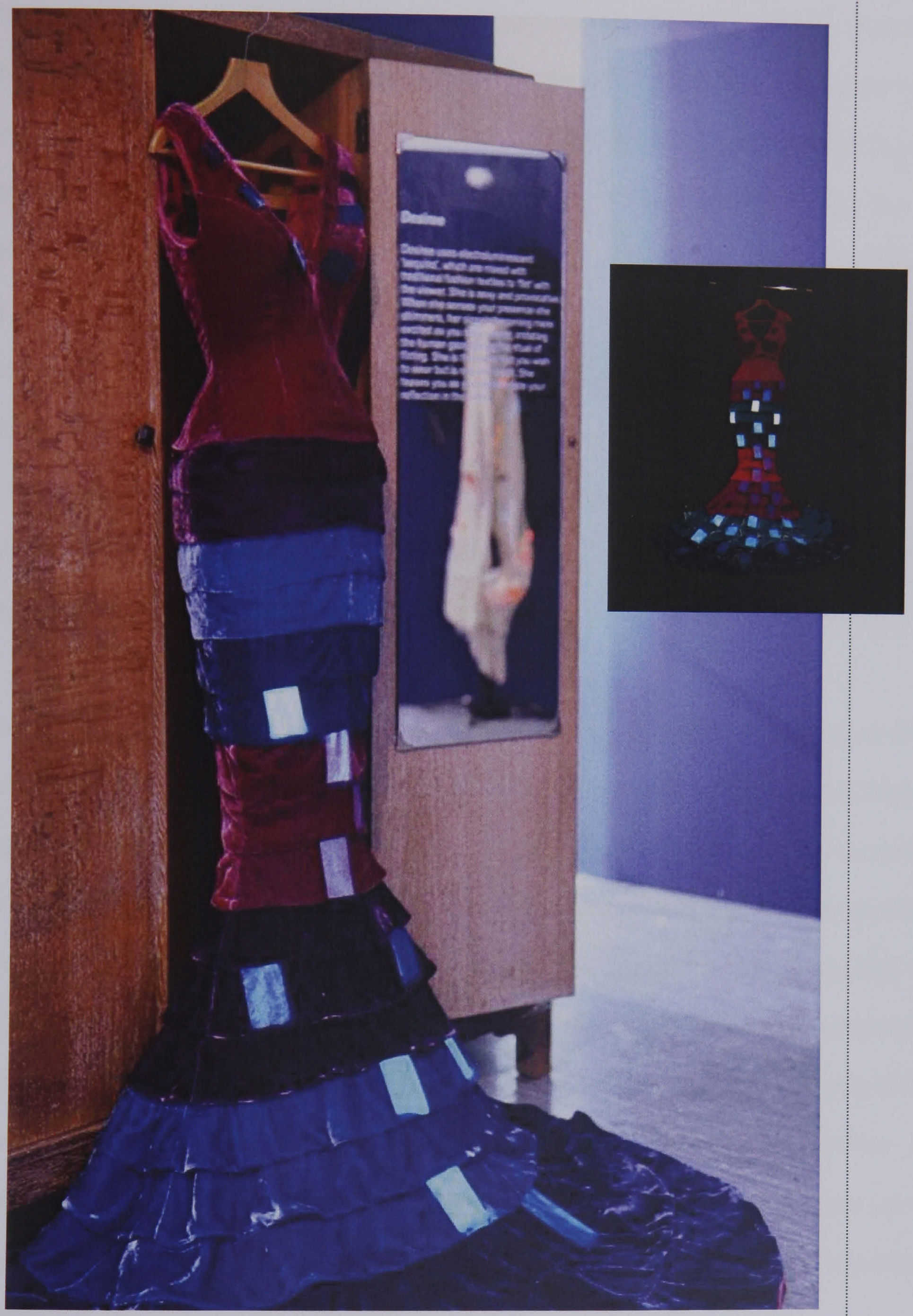

Fig.3. 28.
Desiree (2004), 'living' in a wardrobe at my PhD exhibition and as a video still showing her illuminated in full 'flirt'.
Source: Lisa Stead.

dress is designed to work in the night-light of a bedroom. The colour serves to provide a colour change for an otherwise mono tonal light source but could also be perceived as brash to evoke revulsion as a counterpoint to desire or attraction. The selection of velvet for the dress was also determined by the ability of EL panel to show through high-density fabric. My aim was to mask the plastic covering of the lamps and use the fabric to shade and colour the light. Although the use of velvet provides a sumptuous and tactile finish to the garment, it also creates a bulky aesthetic. When this is considered with the dress silhouette the overall impression is one of 'old fashionedness'. The thickness of the fabric increases with the addition of the EL and the wires that travel underneath the panels. This is especially noticeable around the neckline where the technology is not compatible with the size of the detailing. The EL panels at the neck look clumsy and awkward.

A more contemporary style and perhaps a 'less is more' approach to the amount of EL involved in the dress could help the garment to appear wearable. The *Kinetic Dress* by Cute Circuit (see Practice Review) is a good illustration of this approach: the designers use EL wire as small areas of decoration rather than covering the dress. Alternatively, another lighting technology could be used such as LEDs, which are small, light and can be powered by very thin wiring. However the light from LEDs would be generalized which would provide a very different effect. However, I do feel that the use of the technology and the exaggeratedly shaped dress helped to communicate the characteristics of a flirty dress. In addition the programmable EL drew the eye up the body of the garment to the narrative text and this was enhanced by the installation of Desiree in a wardrobe for the exhibition.

The fact that Desiree did not entirely succeed as a contemporary and believable garment highlights the need for technology-enhanced garments to work as everyday

garments. There are limitations imposed when technology is integrated into clothing to create beautiful and acceptable garments. To help overcome these restrictions a longer design development phase would allow all possibilities to be trialled. Ideally all technology-aided garments could be regarded as wearable and everyday. However, until technology becomes 'fabric' and the cross fertilisation of ideas and disciplines merges into a new form there will be a discrepancy between the concerns of the wearable technology community (for want of a better name), myself included, and the current standards by which garments are assessed. Desiree is a first prototype situated within academic design research. In this context, the garment is of value, offering a greater level of aesthetic consideration than many examples within the field. With further prototyping and greater experimentation a more subtle outcome might be achieved. The most positive outcome of producing Desiree was the knowledge gained about the technological process, which has allowed me to be autonomous. However, I was limited to the use of the technology in its simplest form. To experiment further with the electroluminescent material would have required a substantial financial outlay.

Icaris

Narrative

Icaris suffers from low self-esteem and fear. She has many dreams that she wishes to pursue and longs to have the confidence to 'fly'. Stressed by the pressures of the outside world, she loses her feathers. If encouraged to move her wings, the motion will cool the feathers to aid her flight.

The Icaris narrative was inspired by a short, velvet evening cape and a 70s blouse with crystal pleated, angel sleeves, which evoked the fantasy of flight (Fig 3. 29). To attribute an emotional characteristic to flying, the fear of flying was employed as a theme. The cape was photographed on a tailor's dummy hiding behind the door in a quiet corner of the room to enhance the communication of fear.

Fig.3. 29. Icaris was inspired by a blouse with 'wing' like sleeves and a velvet shrug which 'lived' on a dress stand in the house.
Source: Lisa Stead.

Influence

Fear is characterized in body language by a lack of movement so this contrasted with the notion of flight as motion.[188] The myth of Icarus provided a further focus for the concept because it tells of a boy who wishes to fly and constructs wings made of

[188] Stuart Walton, *Humanity: An Emotional History,* (London: Atlantic Books, 2004),p.1

feathers and wax. Unfortunately, he flies too close to the sun, the wax melts and the feathers fall.[189] This inspired the choice of thermochromic inks to represent the narrative as they are triggered by heat.

Technologies And Why Chosen

Gorix heat pads were chosen to provide a controllable, flat and flexible heat source and a proximity sensor to trigger the garment response. For the colour change thermochromic inks were chosen for Icaris, to extend the narrative of the Icarus myth. The link between heat and colour change, and heat and feather loss, provided a simple but effective analogy. Thermochromic inks are a relatively old material technology but could be used in new ways. As they are already fabric ink they have the potential to become a closely integrated characteristic of the fabric. Although they are less controllable and slower to colour change than lighting technologies, this characteristic could be developed to become an effective part of the narrative.

Objectives Of Icaris

- To make an unworn garment represent fear and evoke pity and fascination.
- To use thermochromic inks in a new and imaginative way.
- To make the technological intervention still look like a wearable garment.

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[189] Robert Graves, *Greek Myths:Ilustrated Edition,*(London: Cassell, 1981), p88

Method Selected

The method selected was to work with and against the material technology to understand its properties and to find a new technique for an older material technology. This knowledge then informed the material use and integration within the garment.

Technology Support

Ben Sheehan, an independent electronics and computing consultant, was employed to provide the technical support for controlling the initiation of the heat pads.

Material Experiments

To understand the properties of the thermochromic inks, a series of material experiments were conducted. The inks were used to represent feathers in a variety of ways and tested on a heat pad to assess their aesthetic and colour change potential. The colour change temperature thresholds that were tested were pink ink at 15°, green ink at 25° and blue ink at 37°.

Firstly, the inks were used to print layers of multi coloured feathers onto silk chiffon fabric pieces (Fig.3. 30). The inks were mixed with a metallic binder to enhance their visibility on the sheer fabric. The printed feathers exploited the ability of the inks to become invisible on the application of heat and with careful use of varying temperature thresholds; an element of movement was achieved. Although successful, this use is very straightforward and produced a flat aesthetic. A three dimensional approach was then considered to add body and movement to the fabric. A chemical binder was added to the ink to allow it to be used as dyestuff. To replicate the look of feathers in a more

three-dimensional way, a variety of natural fibre fabrics were dyed and ripped into strips. The blue and green dyes took well to the fabrics but there was no discernable difference between the pre-dyed and post-dyed pink fabric with a temperature threshold of 15°. The visual effect of the fabric strips was pleasing but the colour change effect was patchy (Fig.3. 31). This was due to the edges of the fabric strips, curling up from the base fabric and losing contact with the heat pad beneath.

Finally, real white feathers were dyed to test for colour adhesion and colour change. Again, the pink dye did not take but the coverage of the blue and green dyes was good. Once the feathers were dyed they changed back to white upon the application of heat. As feathers have a natural ability to trap heat this capacity was evaluated, to see if it could be harnessed to assist colour change timing and controllability. A series of timed trials were conducted with various layers and spacing of feathers. Experiments to see if the heating process could be quickened included attaching a copper wire and tape to the spine of a feather, inserted into the spine of a feather, and applying a foil backing to the rear of the heat pad (Fig.3. 32). The tests were carried out using a Gorix heat pad contained in a calico pouch.

From this series of experiments it was deduced that the introduction of copper wire or tape did not assist heat transferral from the heat pad into the feather. The addition of foil backing did speed up the colour change process from two minutes (for both colours on an all calico background) to one minute. However the foil retained the heat and slowed the cooling process. The test that offered the best overall result incorporated both colour change temperature feathers (blue 37°, green 25°) with a 7.5cm gap between lines of feathers (Fig.3. 33). This test provided the optimum feather coverage and a complete colour change to white in two minutes.

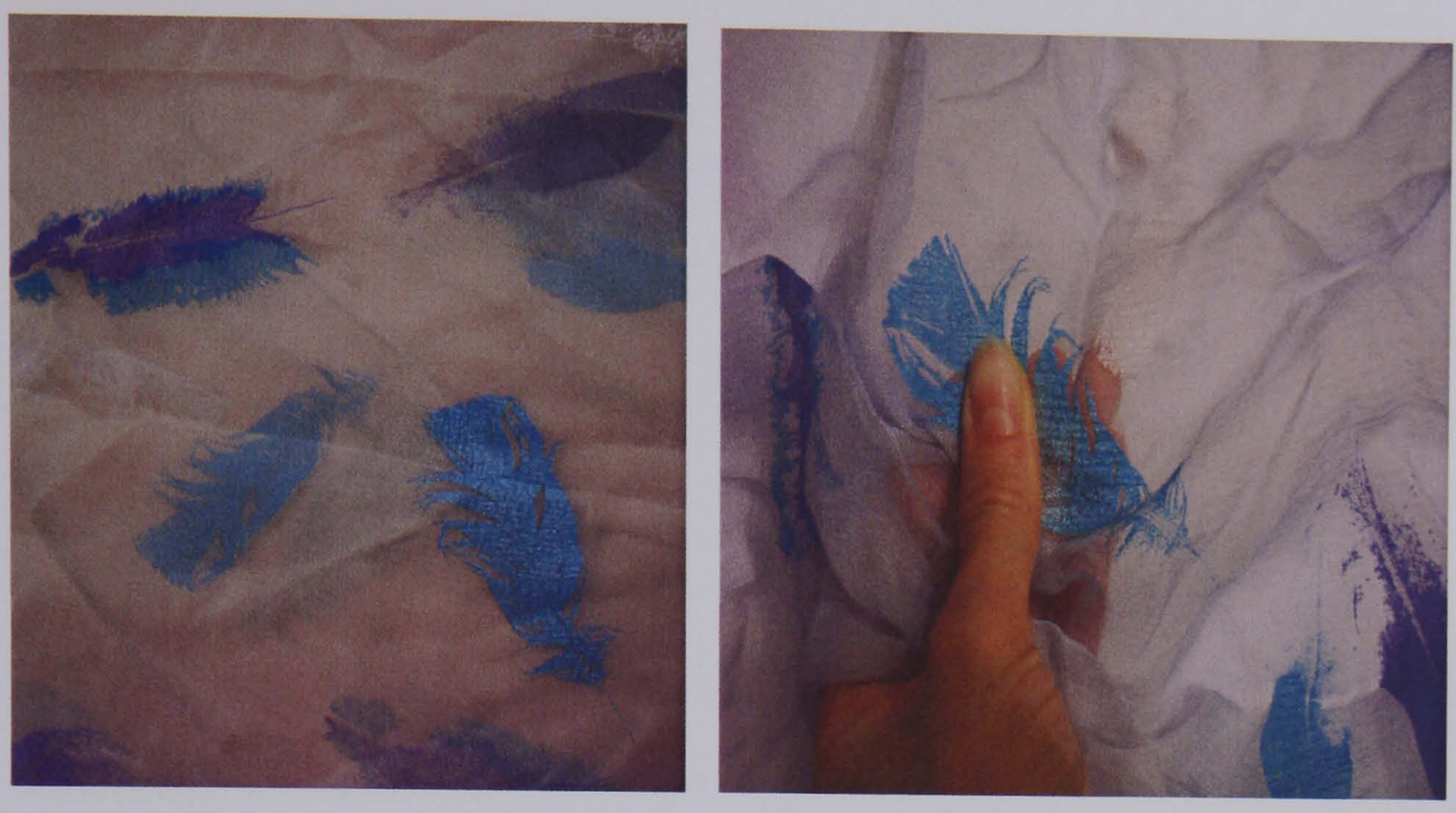

Fig.3. 30.
Firstly, the thermochromic inks were printed using traditional screen-printing techniques.
Source: Lisa Stead.

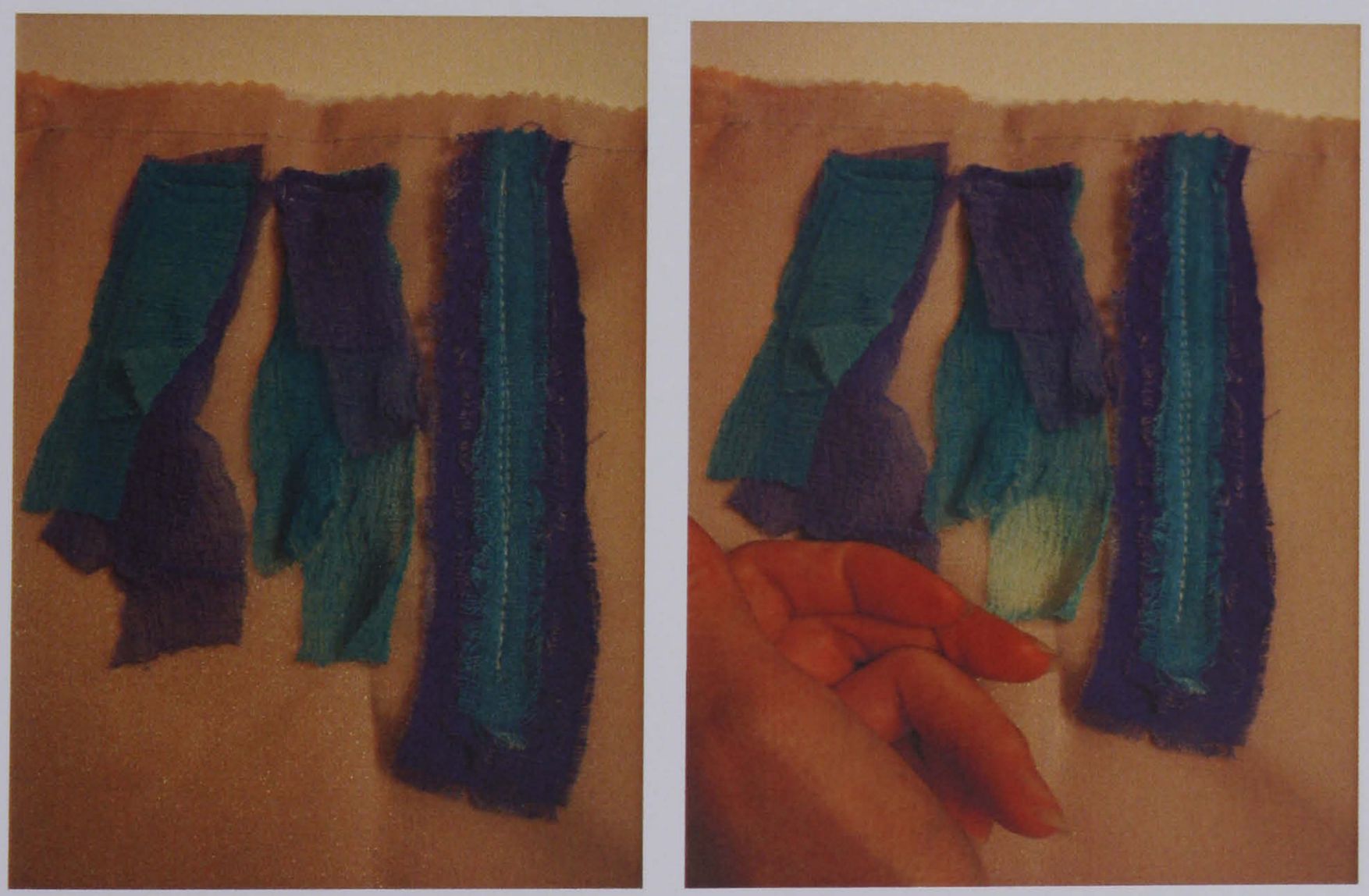

Fig.3. 31.
Next, the thermochromic inks were used as a dyestuff. Various natural fabrics were dyed in the pink, green and blue dyes and then ripped into strips to create 'feather' like textiles.
Source: Lisa Stead.

Fig.3. 32.
A copper wire was inserted into the spine of the feather in an attempt to aid the transferal of heat
Source: Lisa Stead.

Fig.3. 33.
A test with the blue and green feathers provided a complete colour change within two minutes.
Source: Lisa Stead.

Fig.3. 34.
Blue thermochromic feathers were mixed with normal dyed feathers in the same colour to aid a subtle overall look that did not show the shape of the heat pad.
Source: Lisa Stead.

As the heat pads were between 7.5cms and 22.5cm square they created a problem, as the colour change was effected in squares instead of an organic shape. Dying a percentage of the feathers with traditional dyes to match the thermochromic colours so that they could not change colour solved this problem. The feathers were then placed randomly around and in the colour change square to soften the effect of the heat pad (Fig.3. 34).

Fig.3. 35. Various sketches of bolero shaped jackets were designed that played with the proportion of the sleeve to heighten its 'wing' like qualities.
Source: Lisa Stead.

A series of feathered jacket shapes were designed that were influenced by both of the photographed garments. The jacket selected for toiling had the bolero bodice shape of the cape with the over-emphasised sleeve shapes of the blouse (Fig.3. 35). This balance of proportions accentuated the wing like sleeves. The next stage was to produce a series of toiles which were used primarily to balance the proportion of the bodice to sleeves and to trial different lengths and widths of sleeve. Once the toile was finalized the pattern was made up in a two layers of cotton fabric, one to act as a lining. The feathers were stitched to the top layer with a third internal layer housing the heat pads and a covering for the wiring (Fig. 3. 36. See also Unworn and Emovere Films CD to see Icaris change).

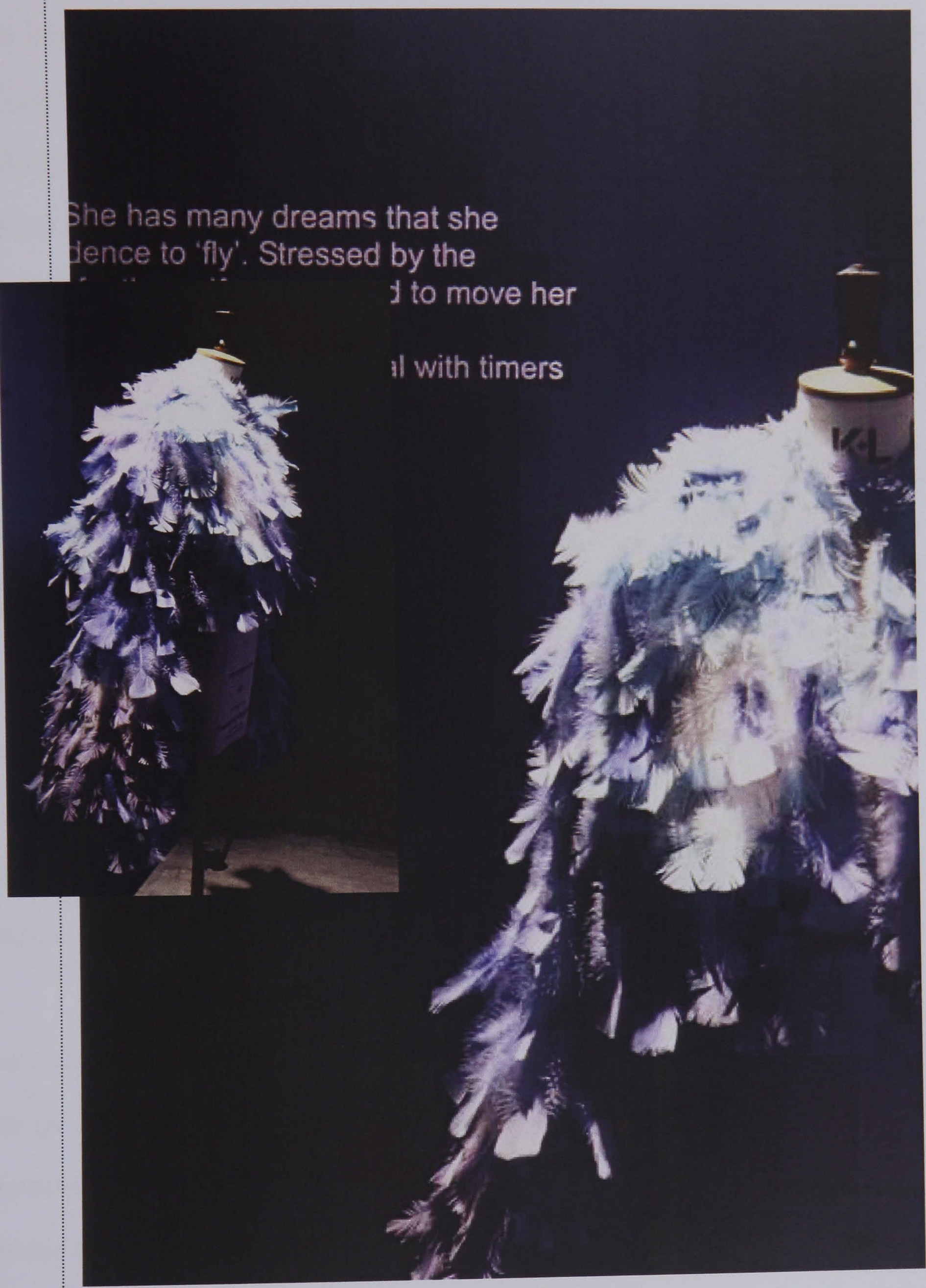

Fig.3. 36
Icaris as an installation at my PhD exhibition.
Source: Claire Robertson.

Revision

The main shift in the production process was the use of thermochromic pigments as dyes instead of inks. This switched emphasis from working with the inks as they are designed to be used, to sit on the surface of fabric, to working against their nature by enabling the pigment to soak into the fabric This transition from printing to dying allowed me to use the feathers to create a three-dimensional rather than flat effect. This change in the focus of the process enabled me to work against previous use of the technology to colour or print flat fabrics and to also serve the narrative purpose of the garment in a very direct and engaging way.

Evaluation

Acquisition of the knowledge required to adapt thermochromic ink into dyestuff enabled me to use a three-dimensional material such as feathers in a garment. This process could be further extended by experimenting with other natural materials and utilising their ability to conduct and insulate heat as a method to effect the rate of colour change.

The use of feathers provided a visual connection to the notion of flight and the colour-change added a magical sense to the interaction. The communication of Icaris's character was enhanced by the colour-change technology. The fading of the colour created a simple link to the loss of feathers. Although the colour change was relatively slow it is controllable and adds a contemplative, gentle element to the experience of the garment. As a fan was used speed up the cooling process of the feathers in the exhibition space it could be beneficial to consider a hot and cold air system to affect the temperature change of the garment. The system could comprise a series of internal

pipes that provide both the temperature change and an increased movement of the feathers, to simulate the notion of flight.

In this case study it could be argued that the garment fitted the technology, rather than the technology fitting the garment, a reversal of process suggested in the Pik Me case study. The material technology was not concealed or hidden by an outer casing of fabric, it is integral to the shape, nature and emotional content of the garment. I did not start the process by observing the emotional qualities of the material as I suggested but by working against the material property and observing its dimensional changes, which then inspired the selection of feathers to fabricate the garment. The choice of feathers has become the emotional character of the garment. In this way the process could be extended to include the observation of representational or associative emotional qualities.

Thermochromic inks used to dye feathers provide the most immersive material technology of all the case studies. The other case studies use traditional textiles to conceal the technology but the thermochromic dyed feathers became the material of fabrication. In addition, Icaris could be worn as a garment and work without the assistance of heat pads and electricity. As a worn garment it could react to body, ambient or environmental temperature changes and be cooled by the movement of the wearer. I feel it is the most successful and engaging of the Unworn garments due to the tactile nature of the feathers, which is further enhanced by the integration of changeable thermochromic technology. The implication is that when a material technology is fully integrated into the fabrication of the garment the result is a more believable garment.

The Worn Garment - Emovere

Emovere also played with concepts of emotion and technology, and was influenced by research into pharmacology, biotechnology, emotional dissonance, affective computing and neuromarketing. The findings suggested a possible dystopian emotional future, where emotions are manipulated through pharmacology not just for therapeutic but also for recreational purposes.[190] Emotions could be engineered with advances in biotechnology, creating a sub-human race. As Francis Fukuyama, asserts,

> The most important component of that whole is the gamut of emotions that every human being is capable of subjectively experiencing…Biotechnology poses a fundamental threat to human dignity because of its ability to manipulate our natures in ways that will ultimately simplify that complexity and reduce us to something that is less than human.[191]

Emotions are becoming increasingly comodified as a job resource evidenced in 'emotional labour' which can lead to emotional dissonance: a condition where the adjustment and repression of emotions to keep employers and customers happy leads to emotional stress experienced by call centre workers and General Practitioners.[192] Furthermore computers are being given the power to recognise, read and even have emotions through affective computing[193] and FMRI (Functional Magnetic Resonance Imaging) brain scanning technologies are being used for neuromarketing, reading brain activity to determine consumers choice of products.[194] Emovere was developed in

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[190] Susan Greenfield speculates with our growing drug culture, that, 'surely we will soon be living in a society of underfulfilled, glassy-eyed zombies ripe for control by a minority'. Susan Greenfield, *Tomorrow's People: How 21st Century Technology is Changing the Way We Think and Feel,*(London: Penguin Books, 2004), p108.
[191] Francis Fukuyama,' Life but Not as We Know It',*New Scientist*, 174, (2002), 42-45 (p.43).
[192] Madeleine Bunting,' Sweet Smiles, Hard Labour', *The Guardian Weekend*, 12 June 2004, p.16-22, and, P.R.Vidyarthi, "I am Smiling…but I don't Like You", *India Infoline.com*, (18 August, 2003) <http:// www.indiainfoline.com/bisc/iams.html> [accessed 27 May 2004].
[193] Rosalind Picard, *Affective Computing* (Cambridge, Massachusetts: The MIT Press, 1997).
[194] Ian Sample and David Adam, 'The Brain Can't Lie', *The Guardian,* section Life, 20 November 2003, pp.4-6.

reaction to this bleak picture, as a means to communicate and celebrate strong emotions in all circumstances. It also suggests that fashion can be used to conceal our true identities but a dress that communicates emotion might provide another level of meaning.

Objectives Of Emovere

- To facilitate greater personalisation of garment displays through technology altering the communication possibilities of fashion.
- To make a worn garment represent and express emotions.
- To integrate electroluminescent or LED technology in a garment.
- To make the technology wearable.
- To use technology to monitor emotions.

Process And Method

The process of development began with the selection of a suitable lighting technology to match the level of controllability required by the garment. Experiments with EL were conducted by working with or against its inherent properties to aid understanding. This knowledge then informed the use of EL in the garment. The display program model was selected and the garment design developed. Affective computing was the method selected to monitor and express emotions as this provided a means to infer emotion from physiological signals. A group of actresses were tested to gather emotional data for the dress and the integration of the technology within the dress was considered. The dress was then programmed to further enhance the emotional aesthetic display.

Technology And Why Chosen

EL panels were chosen for the garment display as they provided a flat, flexible and controllable form of light and colour.

Technology Support

Imperial College, London, provided the affective computing expertise, developed the sensors and designed the circuits for the lighting display. The initial technology for the sensors, the lighting display and the AffectiveCoder software was developed by a group of final year MA Electrical Engineering students. Petar Goulev, a final year PhD student in Electrical Engineering and affective computing developed the AffectiveWare platform, the system that is able to collect and analyse the emotional data. He also took over the further development of software and implementation of the technology within the dress, and developed the programming system for the garment display.

Material Experiments

The first stage of the process was to understand the properties of EL so that I could exploit its characteristics for aesthetic purpose. As The EL and its inverter were still under development, the EL was attached to electronic equipment on the work bench. This meant that I was forced to test the EL panel against swatches of fabric. This made the experimentation process very difficult and partially speculative. Working with and against the material, I observed the effects of weaving the EL (Fig.3. 37), covering it with a cut-out and interlaid fabric (Fig.3. 38) and punching holes in a fabric overlay to

Fig.3. 37.
'Mock' EL panels were woven with toile to produce a basket weave effect for sections of a garment. However when the EL panels were bent they produced an audible hum.
Source: Lisa Stead.

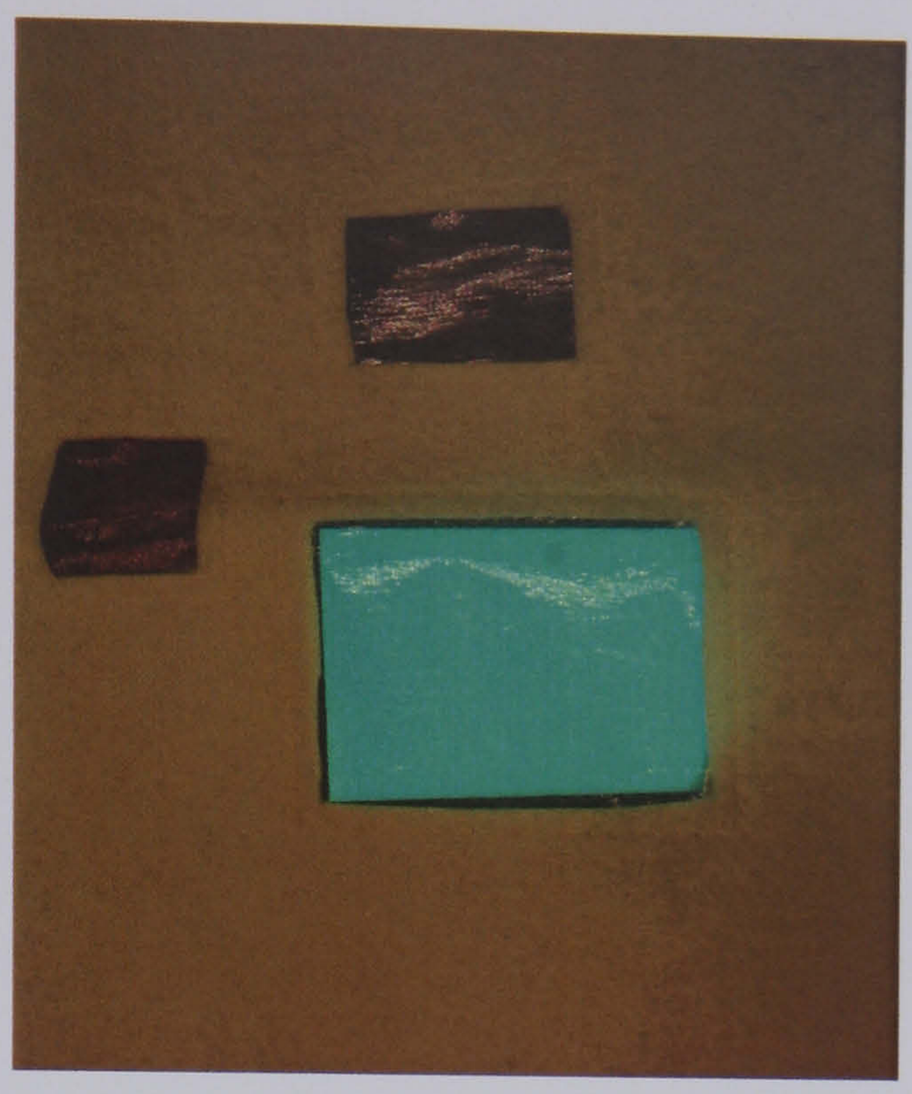

Fig.3. 38.
Iridescent fabrics were sewn into cut-outs in fabric samples and the look of the EL through the fabric assessed. The El panel was still very evident behind the fabric covering.
Source: Lisa Stead.

enable the light to shine through (Fig. 39).[195] From this series of experiments I observed that weaving the EL caused it to hum and the plastic casing was still very visible, a problem that was also apparent in the cut-out trial. The hole-punch aesthetic was successful as it managed to cover the plastic nature of the EL panel and to control the intensity and colour variation of the light. Three dimensionality was explored by using a felt base fabric that could be molded into contours, thus allowing the EL light to seep from the interior of the garment (Fig.3. 40).

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[195] Punching holes in the fabric was inspired by 'gestural embroidery', a term derived from the traces that people make in the air with their arms and hands when talking expressively. If this option had been chosen the holes would have reflected a different trace for each emotional expression on the surfaces of the garment. See, David Efron, 'Gesture, Race and Culture: A Tentative Study of some of the Spactio-temporal and 'Linguistic' Aspects of the Gestural Behaviour of Eastern Jews and Southern Italians in New York City, Living Under Simliar as well as Different Environmental Conditions (Excerpts)',in *Social Aspects of the Human Body; A Reader of Key Texts,*ed. byTed Polhemus (England: Penguin Books, 1978), pp. 224-247, p.229.

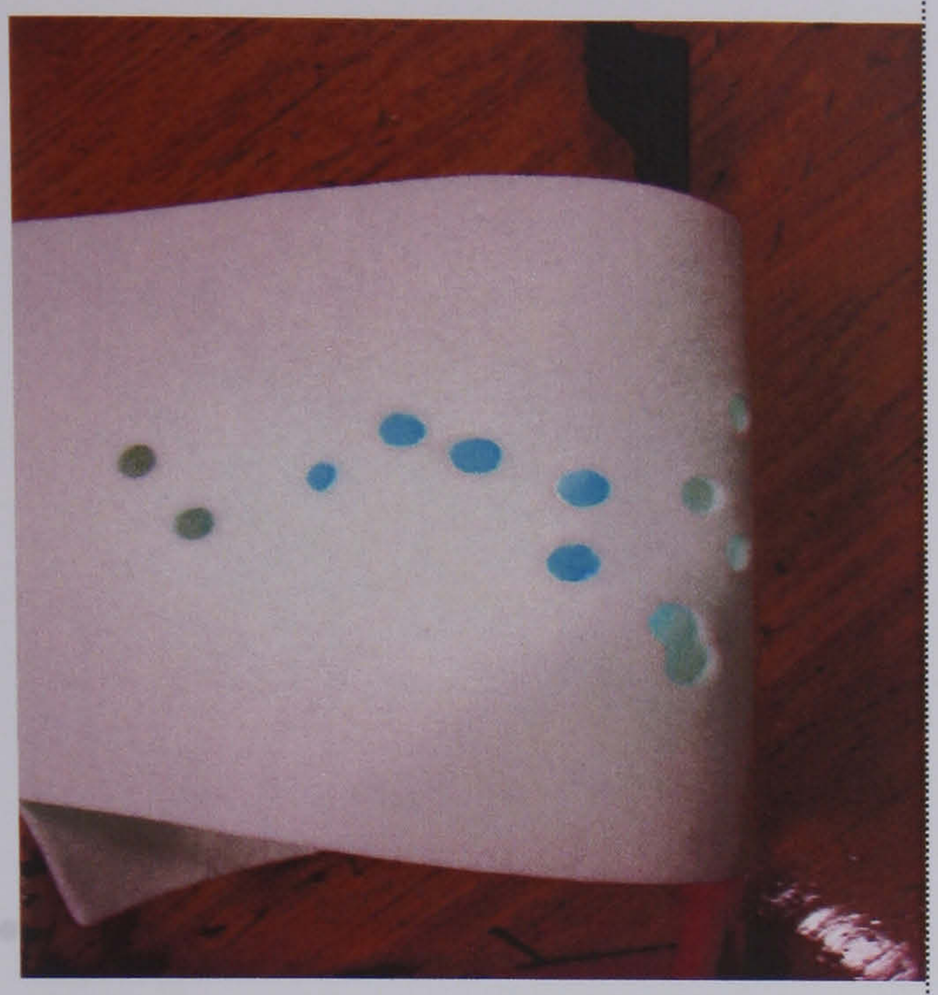

Fig.3. 39.
Holes were punched into the fabric to allow the light from the EL panel to shine in a decorative manner. The swatch was then rolled to create a three-dimensional effect which played with the shading of the light. This experiment was inspired by the concept of gestural embroidery.
Source: Lisa Stead.

Fig.3. 40.
The EL panel was held inside a fabric contour which allowed the light to reflect out onto the surface of the fabric.
Source: Lisa Stead.

An added advantage of the contour approach was the ability of the space to house the EL panel. By creating an insert to support the contour, the EL panel could also be held at a 45°angle to optimise the glow of light (Fig.3. 41). A further series of experiments were conducted to transfer the light from the contour onto the surface of the garment. Undulations were created by moulding and steaming the felt fabric before the application of binder, film and foil (Fig.3. 42). Pearlised binder, film and foil were adhered to the face of the felt, as both a flat and an undulating surface (Fig.3. 43). From this information the pearl binder printed onto close undulations was evaluated as the most affective 'carrier' of the light from the contour.

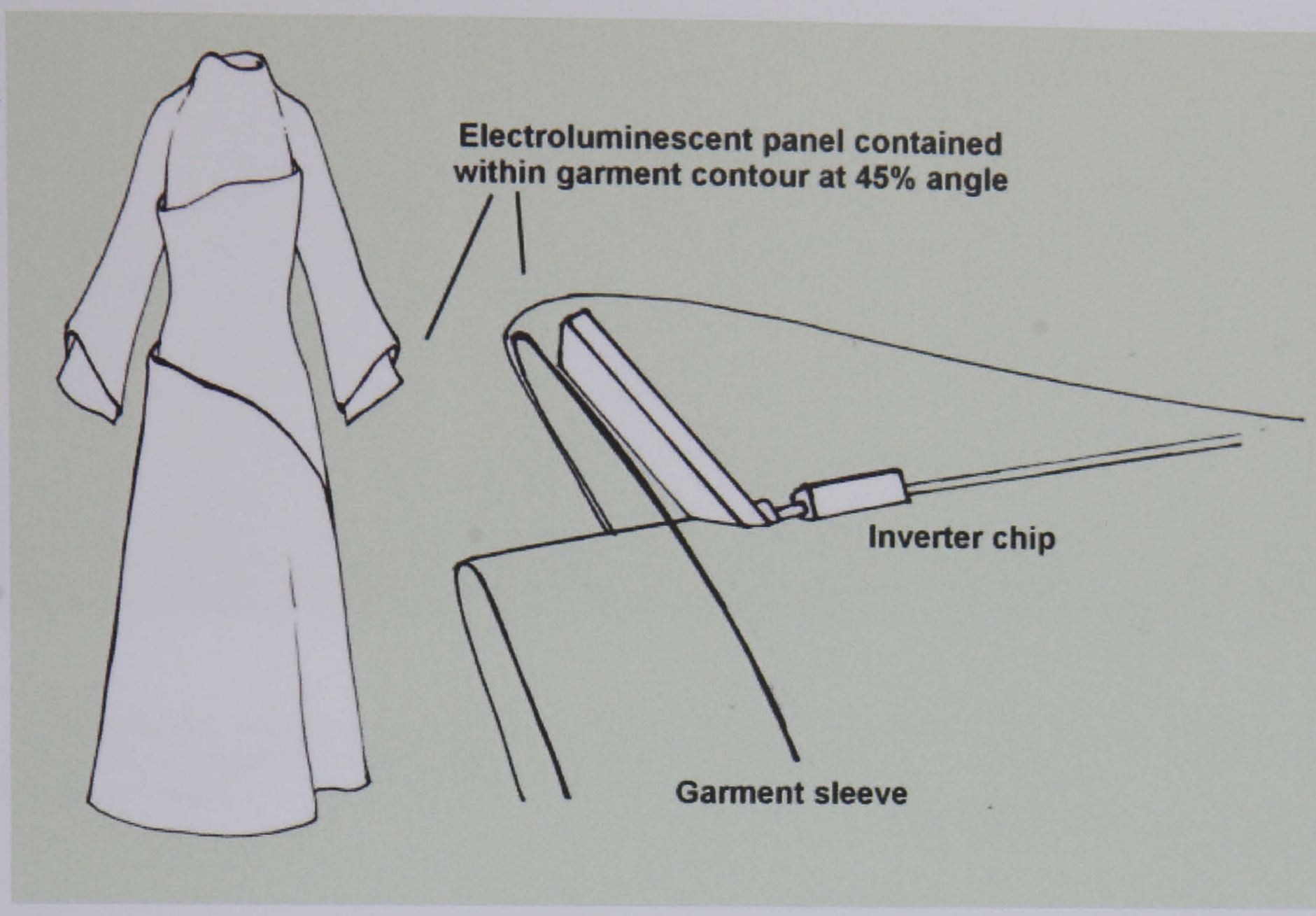

Fig.3. 41.
The contour device was chosen as it hid the EL panel and created a poetic use of light. The EL panel was supported within the garment contour at a 45° angle.
Source: Lisa Stead.

Fig.3. 42.
Fabric swatches were also steamed to create undulations in the surface of the fabric to aid the transfer of light across the garment.
Source: Lisa Stead.

Fig.3. 43.
Various reflective materials were applied to the surface of the fabric to aid the transfer of light. Pearlised binder, film and metallic foil were applied and assessed for suitability.
Source: Lisa Stead.

Display Rules

The next stage was to devise a model for the display program or 'display rules'.[196] This would enable the light display to express each of eight emotions as suggested by Plunchik: joy, sadness, anticipation, anger, fear, acceptance, disgust and surprise.[197] The display rules are based on the analogy of music and emotion, as there are close relationships between the body and music (Fig. 3. 44).[198] This model also provides an

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[196] 'Display rules' is a term used by basic emotion theorist, Paul Ekman, to refer to the cultural norms in different societies that are developed to manage emotional expressions. They are used here to describe the display programs. Joseph LeDoux, *The Emotional Brain: The Mysterious Underpinnings of Emotional Life* (London: Phoenix, 1999), p.117

[197] Robert Plutchik's model of basic emotions was chosen for the dress. He visualizes the eight basic emotions as sections of a circle similar to an artisit's colour wheel. The basic emotions that are next to each other are blended to create primary dyads, those an emotion apart are secondary dyads and so on. This model suggests that all emotions, except the basic emotions, are combinations of each other. Joseph LeDoux pp 133-134. Although there is no consensus as to what the basic emotions are, the analogy with an artist's colour wheel and colour blends was seen as apt for a design research project.

[198] Bresin and Freiberg's work in evaluating the emotional valence of the listener to a specific piece of music culminated in a project to use the emotional characteristics to make ring tones more emotional. I listened to their characterisations of emotional musical phrases, noted what I heard and also looked at the graphs of their musical readings. These clearly illustrated their

abstract communication of emotion so that the wearer could retain emotional privacy when in public but loved ones might learn to read the program over time. To inform the movement of the light over the body, research into body language was consulted. The body was defined as body 'zones' depending on its generalised use when expressing emotion (Fig. 3. 45), These two models were combined to specify the rhythm of the light pulses and order in which the individual lights were triggered (Figs.3. 46 and 3. 47). [199]

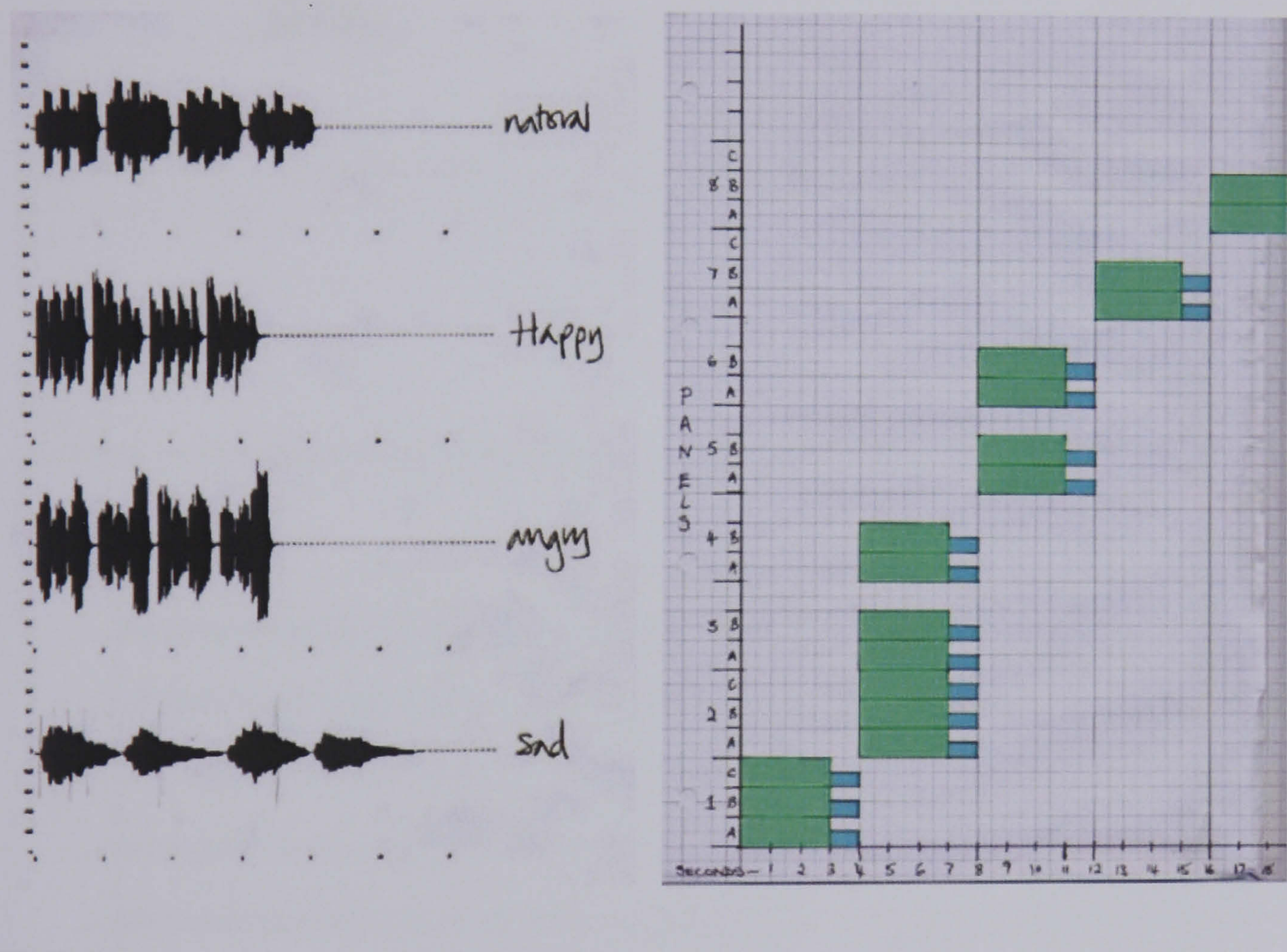

Fig.3. 44.
Research into music and emotion by Roberto Bresin and Anders Freiberg inspired the structure of the display rules. Their visualization of emotional characteristics can be seen alongside an initial plan for a light 'score' of sadness.
Source: http://www.speech.kth.se/music/mobilephone/icad2001_expressive_musical_icons.htm

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findings and the breakdown of emotional 'features' in each phrase. These qualities were used as models for the display rules. See Bresin, R., and A. Friberg, 'Emotional Coloring of Computer-Controlled Music Performances', *Computer Music Journal* ,4 (2000), 44-63 and *Music and Emotion:Theory and* Research, ed.by Patrik N. Juslin and John A. Sloboda (Oxford: Oxford University Press, 2001)

[199] The colours for the display were not chosen to signify psychological associations with colour but to represent sound intensity. As green LED light is visually brighter than the blue, it was used to represent louder tones, the blue signifying quieter 'notes' or emotional phrases.

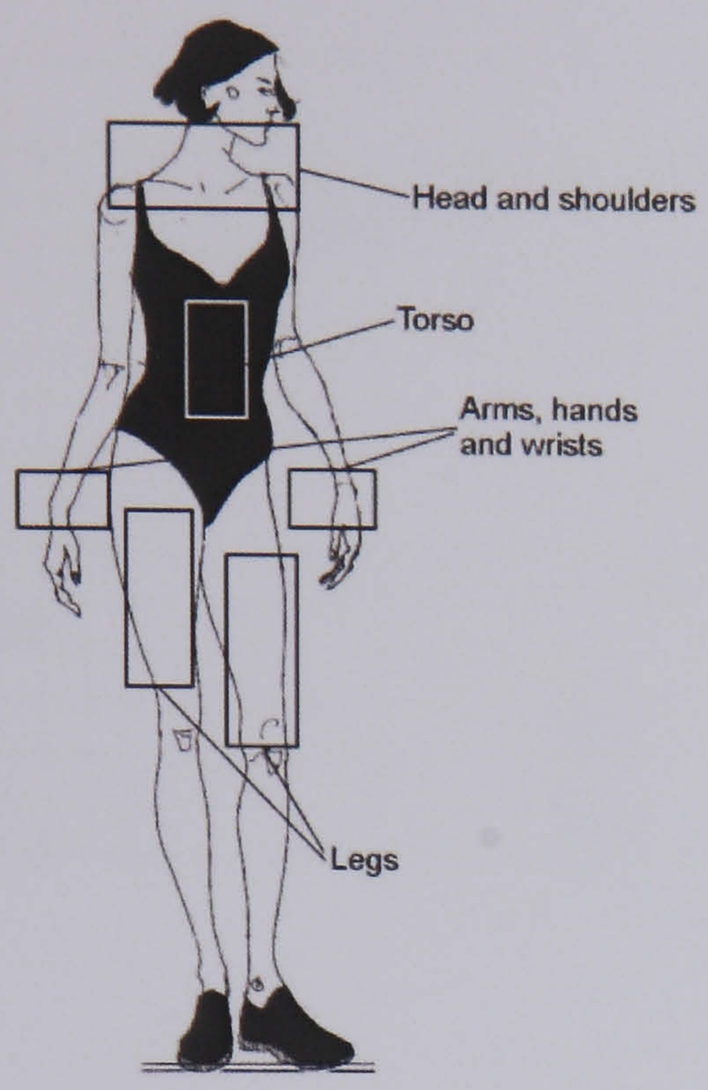


Fig.3. 45.
Body zones. Source: Lisa Stead.

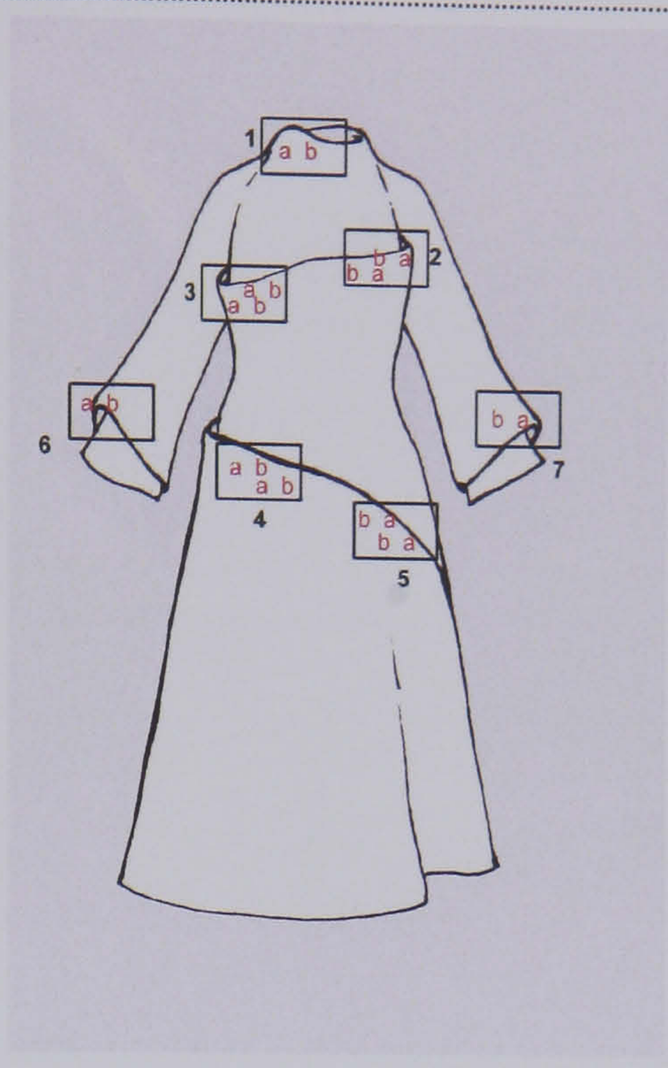
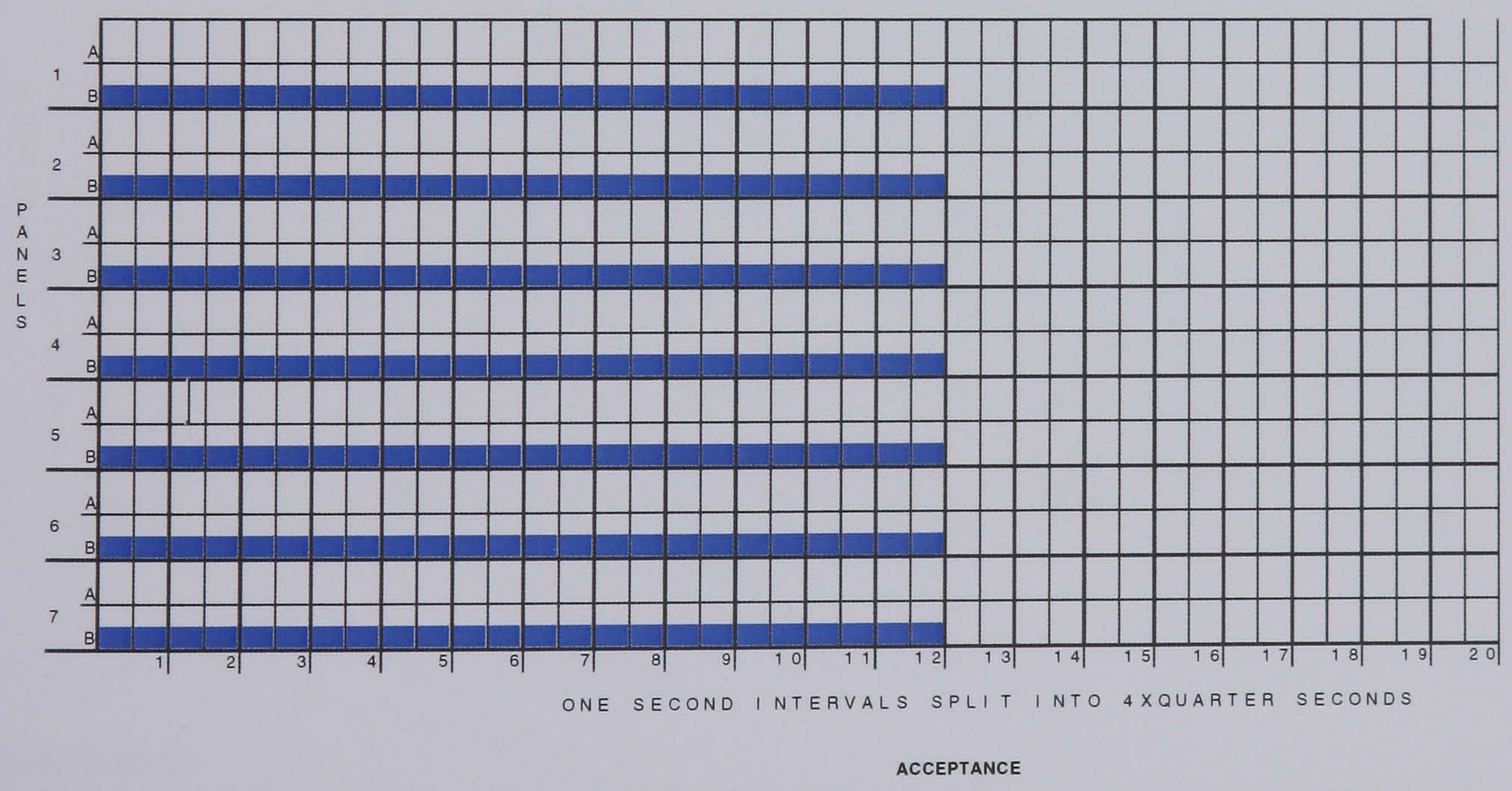
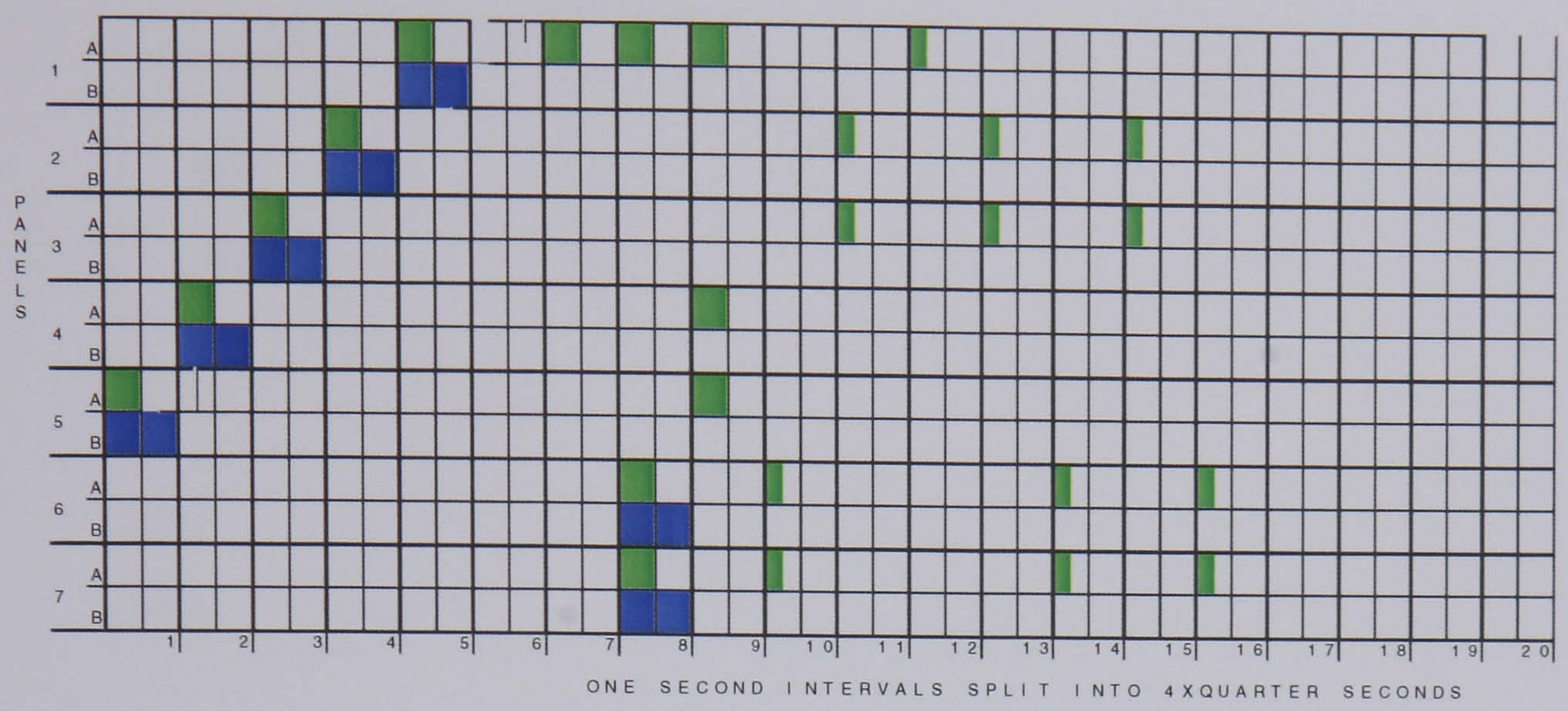


Fig.3. 46.
This diagram shows the positioning of the LED circuits within the dress. A= blue, B= green.
Source: Lisa Stead

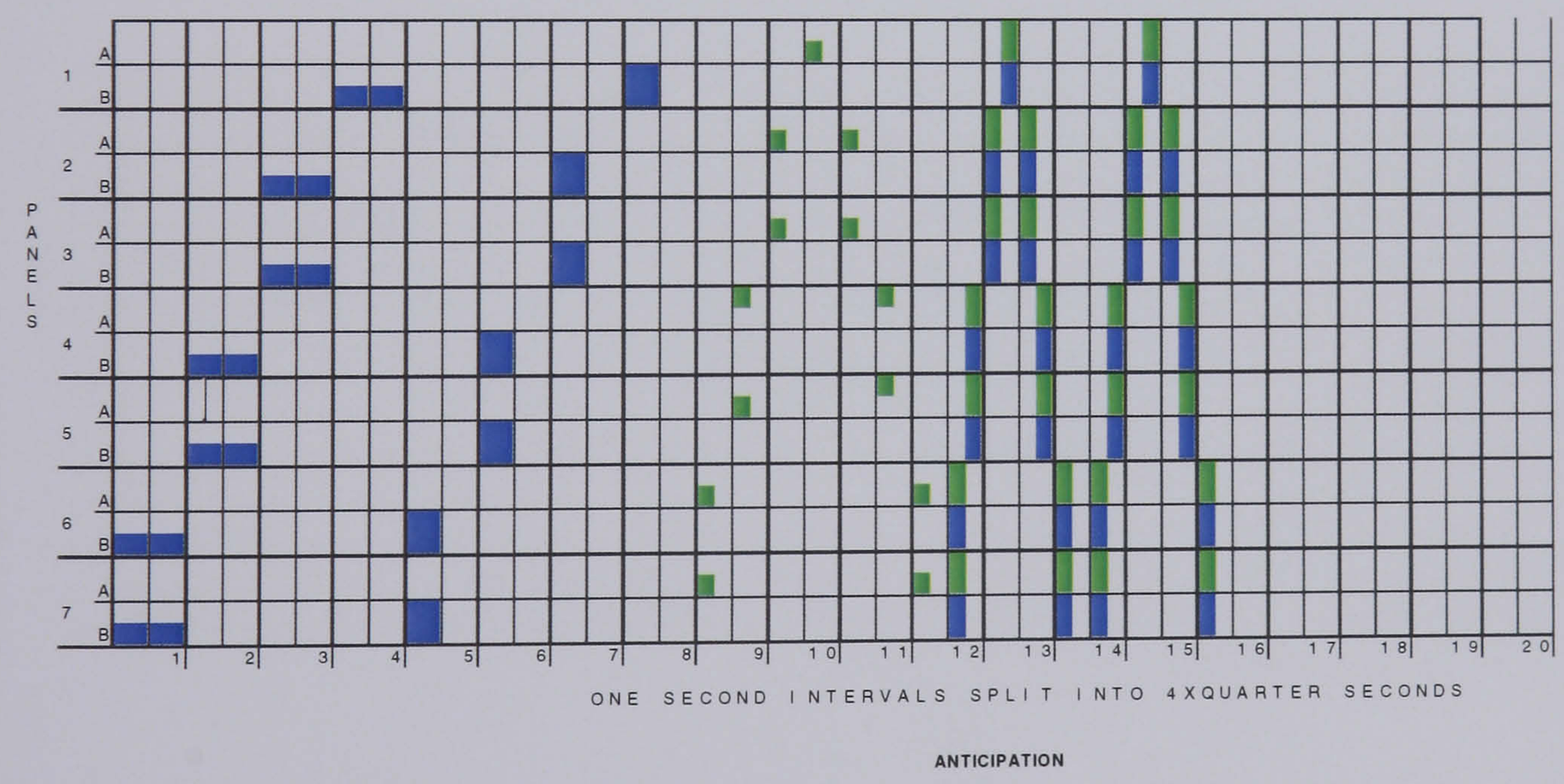
Fig. 3. 47.
Light scores and descriptions for eight emotions.



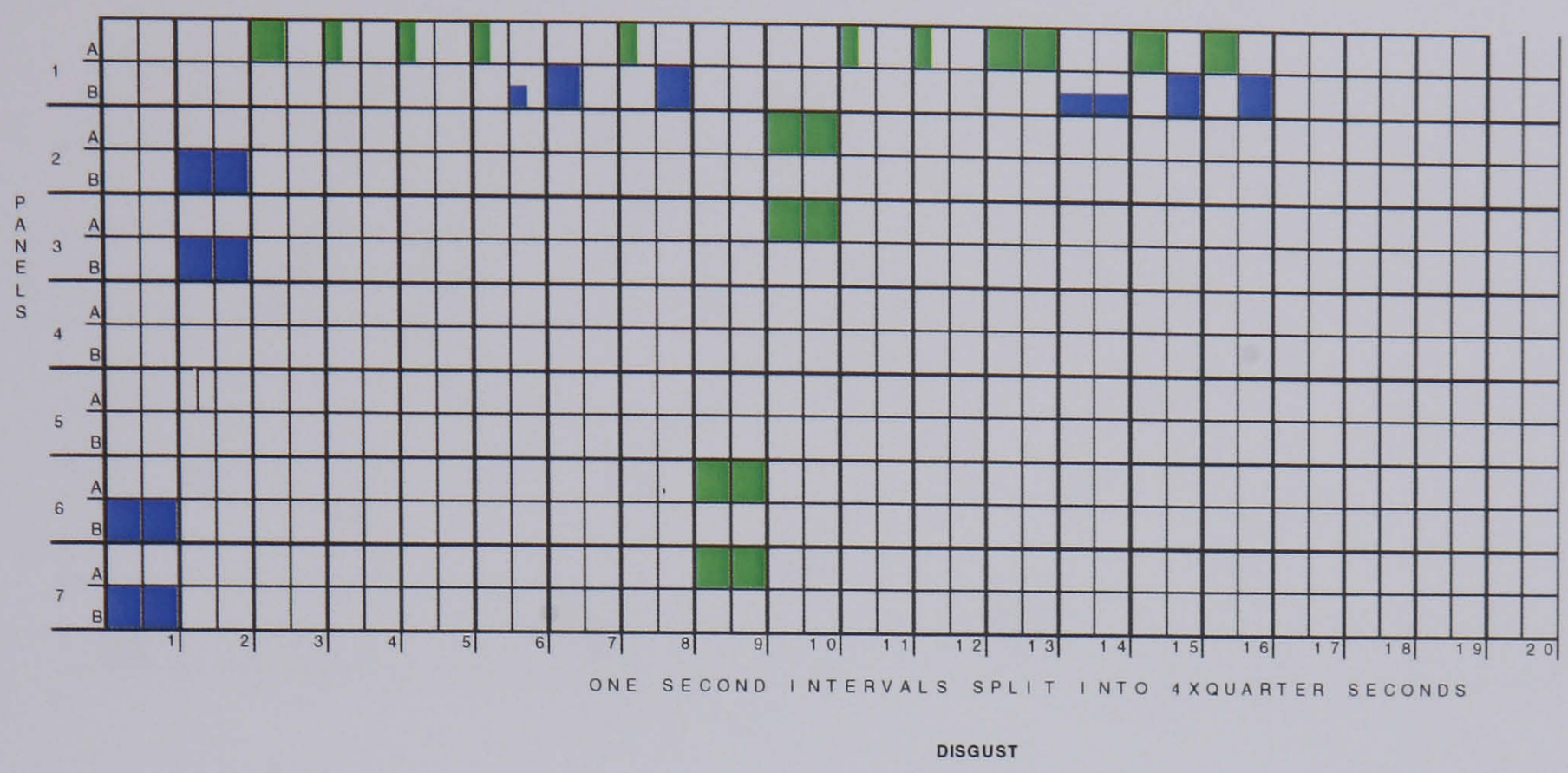
Acceptance
Acceptance is represented by a long, constant blue pulse. This arrangement is shown on all panels at the same time to reflect an even tempo and body language.
Source: Lisa Stead



Anger
One-second, blue light pulses followed by half-second pulses represent growing agitation and anger. The display sequence moves up the torso and remains at the neck flickering, reflecting an upright torso and a jerking of the head. At the wrist, the panels light up from the outside, moving inwards to the hip panels, conveying a palm down expression and hand on hip body motion associated with anger.
Source: Lisa Stead

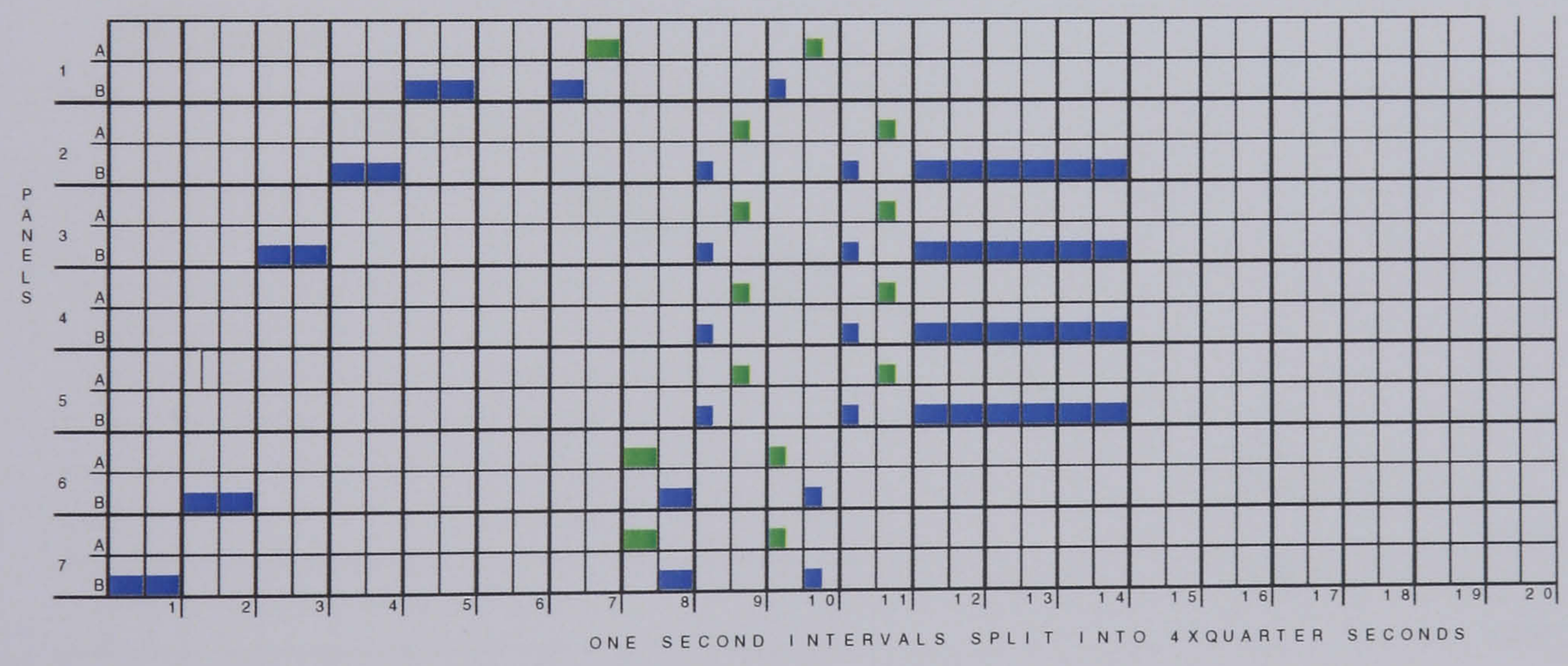


Anticipation
Anticipation begins as long blue pulses of light which shorten and build in tempo becoming bright green flashes. Finally the blue and green lights are displayed together creating a bright white light emphasising the building anticipation. The movement of the display sequence shows building and decreasing tension by moving up and down the body.
Source: Lisa Stead



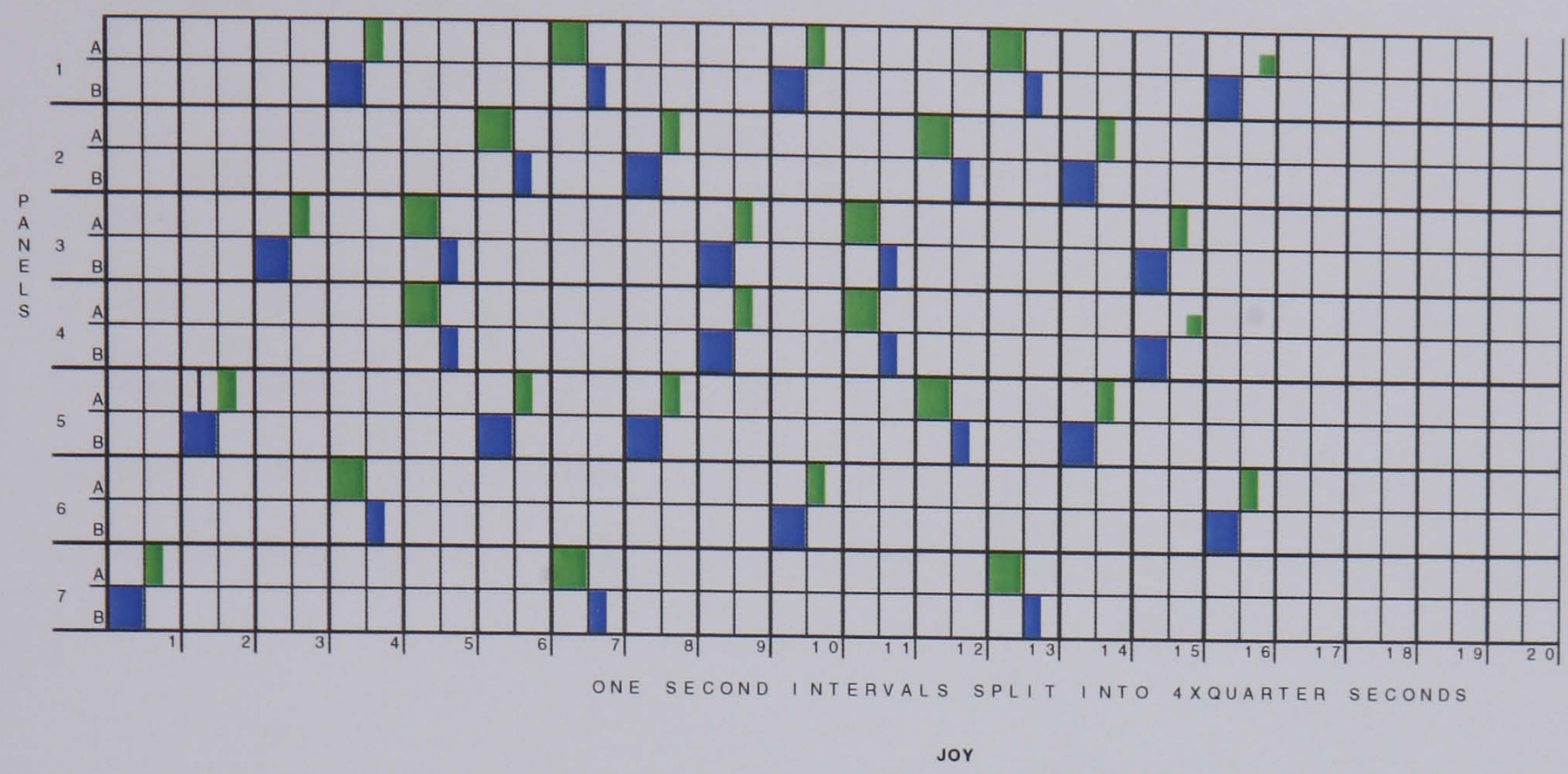
DISGUST

Disgust
Disgust is represented by blue to green light pulses in an increasingly quicker tempo. The light ascends the body from hand to torso to head, reflecting a hand to mouth movement.
Source: Lisa Stead

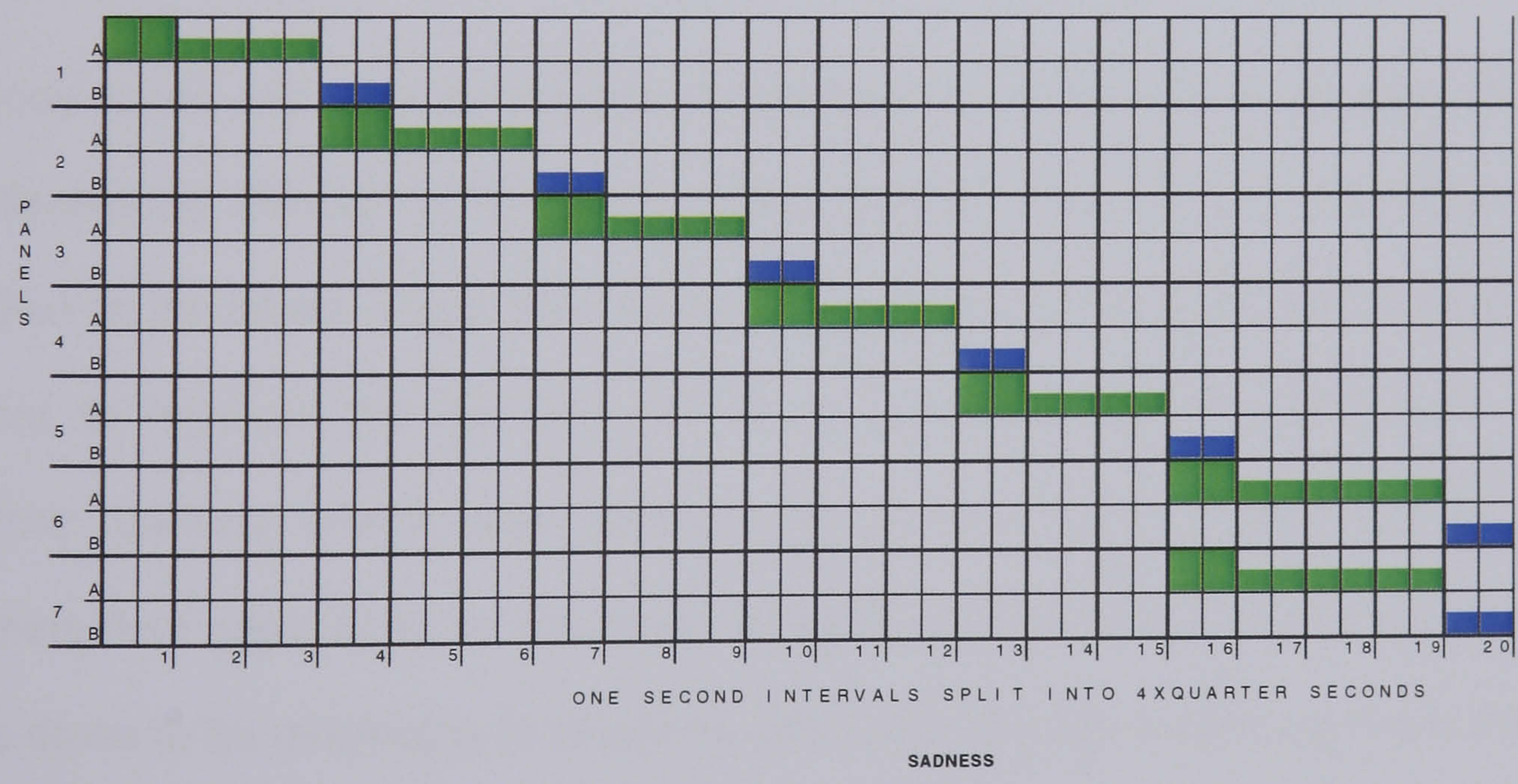


FEAR

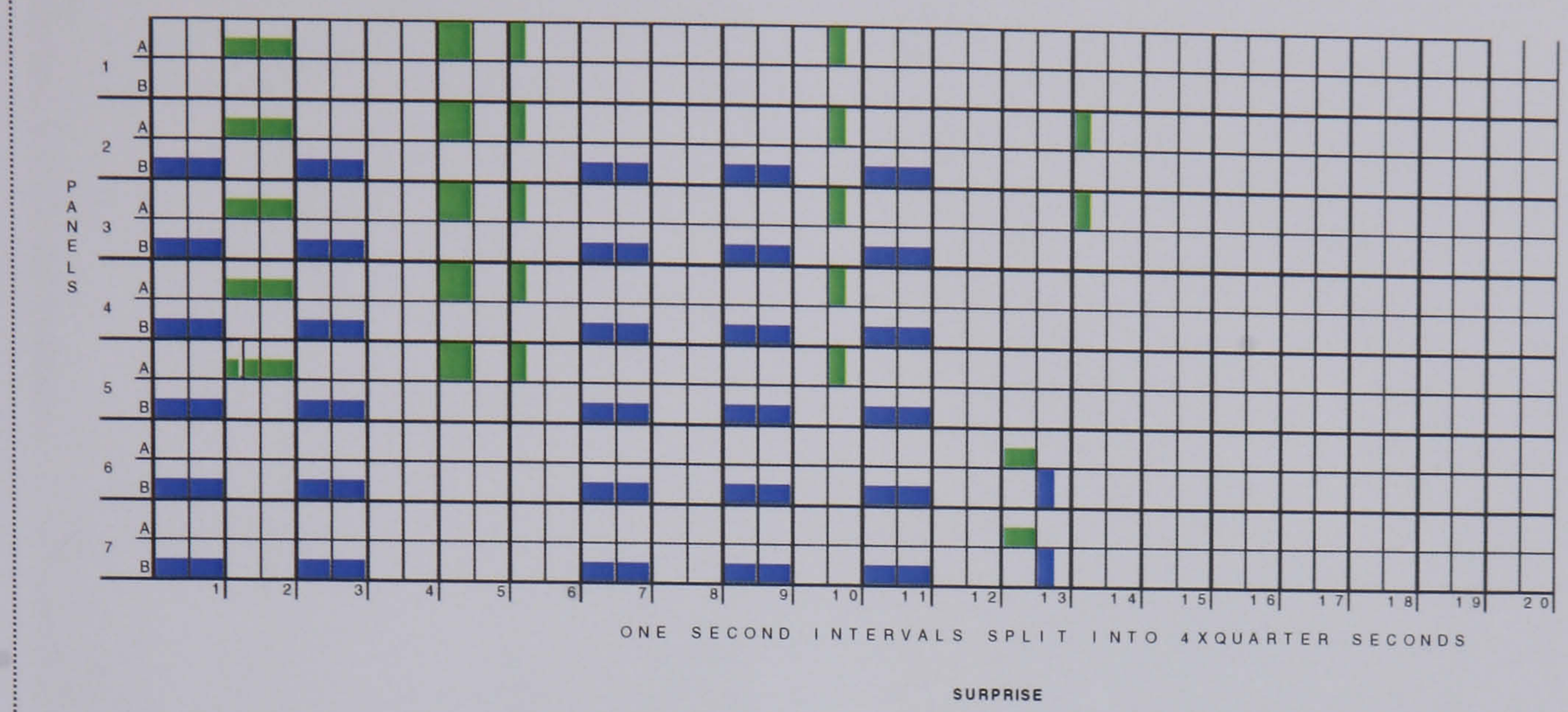
Fear
Fear is visualised by pulses at irregular tempo, expressed in mainly staccato articulation. The phrase ends with a long, low intensity blue pulse. The panels are sequenced to move into the centre of the body and remain stationary, reflecting a crouching motion followed by a frozen stance.
Source: Lisa Stead



Joy
Syncopated, fast tempo pulses in alternating blue and green light are used to express happiness. The panels are illuminated in diagonal arrangements across the garment to mirror swinging arms and 'joyful' body movements.
Source: Lisa Stead



Sadness
Sadness becomes long, slow, green pulsations corresponding to a slow tempo and 'legato' articulation. The panel is changed to blue at the end of the phrase, to express a dip in tone and volume. The panels pulse in a descending display to mirror the slumped posture of the body when expressing sadness.
Source: Lisa Stead



Surprise
Mixed rhythms of long and short duration correspond to light blue and bright green light signifying calm and shocked intervals. These are interspersed with short, 'staccato' light pulses in green. The sequencing appears on all panels to represent a body 'shock'.
Source: Lisa Stead

Garment Design

The body zones also provided a model for the contour placement on the garment which was developed through a series of design sketches and paper and fabric toiles modelled on the stand (Fig.3. 48) The dress was purposefully designed as a full-length garment to highlight the fact that the dress both conceals the body and reveals emotions. Various fabrics were toiled, such as felt, cotton, denim and velvet, to determine their capacity to be moulded and carry the light (Fig.3. 49). It was important for the dress to be mouldable to dispense with darts, to keep a sleek garment aesthetic and to allow the light display to become the focus. As the EL panels were still undeveloped laminated card was substituted in the toiles as it represented the same size, shape and weight as the technology.

Fig.3. 48.
The garment design was initially modelled in paper before it was toiled in felt fabric.
Source: Lisa Stead.

Fig.3. 49.
Aspects of the design were also toiled in denim but the fabric did not carry the light sufficiently.Source: Lisa Stead.

Emotion Testing

The next stage of the process was to gather emotional data for the AffectiveWear platform so that the dress could be tailored to an actress's emotional response. Six actresses were selected to evoke Plunchik's eight emotions whilst wearing a galvanic skin response sensor (Fig.3. 50). A galvanic skin response sensor measures the conductance of electricity across the surface of the skin. A heart rate and temperature sensor is also being developed that will eventually be integrated into the AffectiveWare platform. The actresses were recorded as they acted each emotion repeatedly for a minute and a half, followed by a calm period of the same duration (Fig.3. 51). This created clear demarcations between the readings. The actresses were also video recorded so that body language, facial gesture and speech intonation could be assessed. The data was analysed and the actress with clearest readings selected.

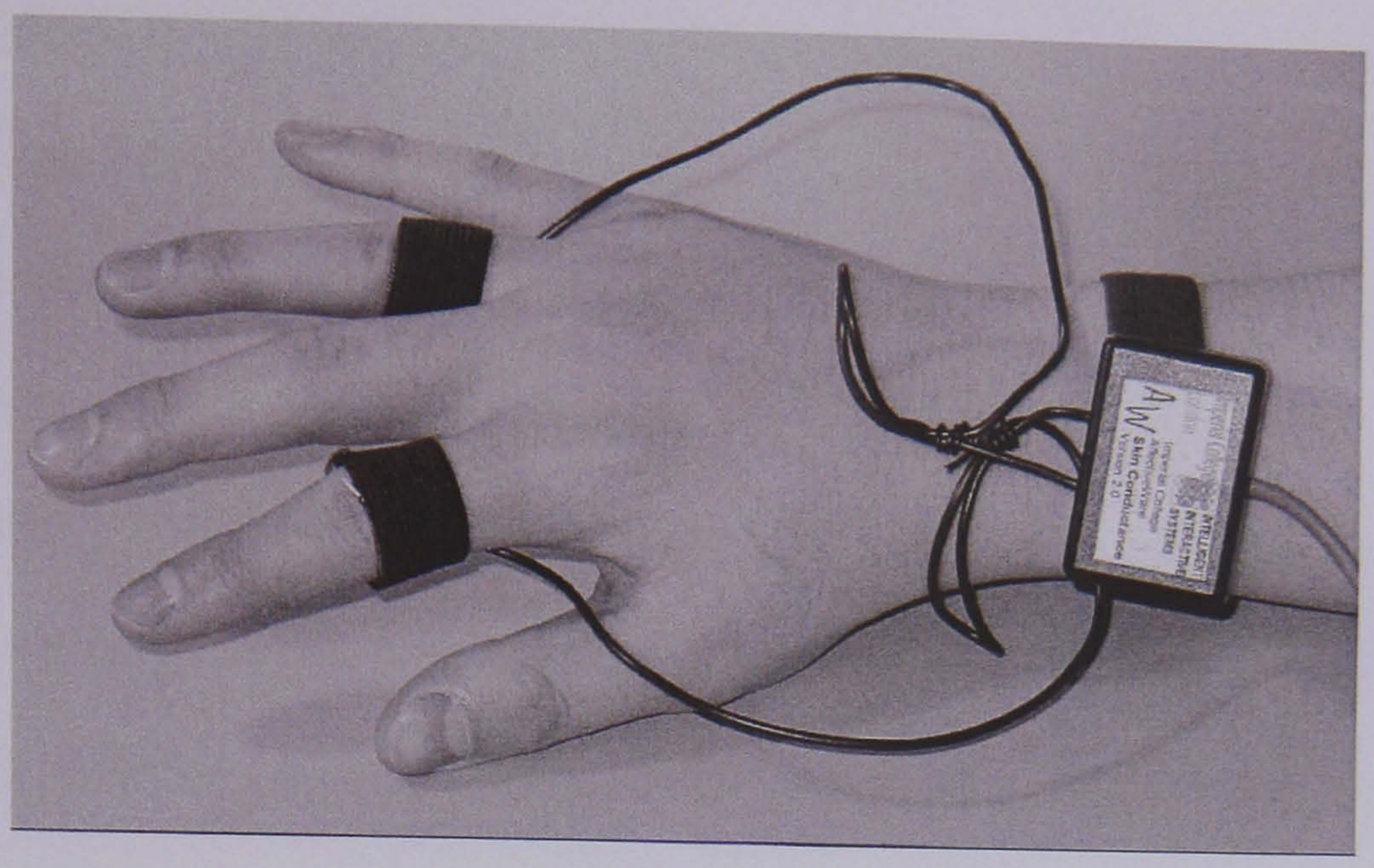


Fig.3. 50.
A galvanic skin response sensor measures the conductance of electricity across the surface of the skin. Source: Petar Goulev

Fig.3. 51.
An actress expressing fear, acceptance, surprise and sadness during the emotion testing for Emovere. Changes in emotion are reflected in the patterns of data visualized in the graph.
Source: Lisa Stead.

Data Flow Of The Garment

As the technology for the garment was still being developed I produced illustrations of the garment system so that I could envisage how the technology could work with the dress. The system consisted of sensors, EL panels, wiring the AffectiveWare platform, a garment server and a display controller and other hardware powered by three mobile phone batteries which needed to be carried on the body. The lighting technology was to be accommodated in an overdress and the sensors and the AffectiveCoder in an undergarment. This was to ensure that the sensors were in close contact with the body at all times and that the lighting could be housed in a more generously contoured overgarment.

Emovere includes a set of sensors. The system is configured from an undergarment and overgarment. The undergarment contains the AffectiveSensors and the AffectiveCoder whilst the overgarment houses the EL display panels. The data flow for the Emotional Wardrobe is explained as follows, (Fig.3. 52). The physiological sensors send data to the AffectiveCoder, which translates the analogue information into digital signals. These signs are transmitted wirelessly to the AffectiveWare Platform, which estimates the mood of wearer and passes the information to the garment server.

To personalise Emovere the wearer could select from the display rules (if several sets of emotional scores were designed) or define their own display rules (see Display Program). The wearer's choice is sent via a Personal Digital Assistant or a mobile phone to the garment server in preparation for a garment response. The garment server attributes a display rule to an inferred emotion and this command is sent to a Bluetooth enabled display controller which is circuitry built into within the over garment.

The controller reads the instructions from the server and changes the display to create a changing aesthetic depending on the inferred emotion.

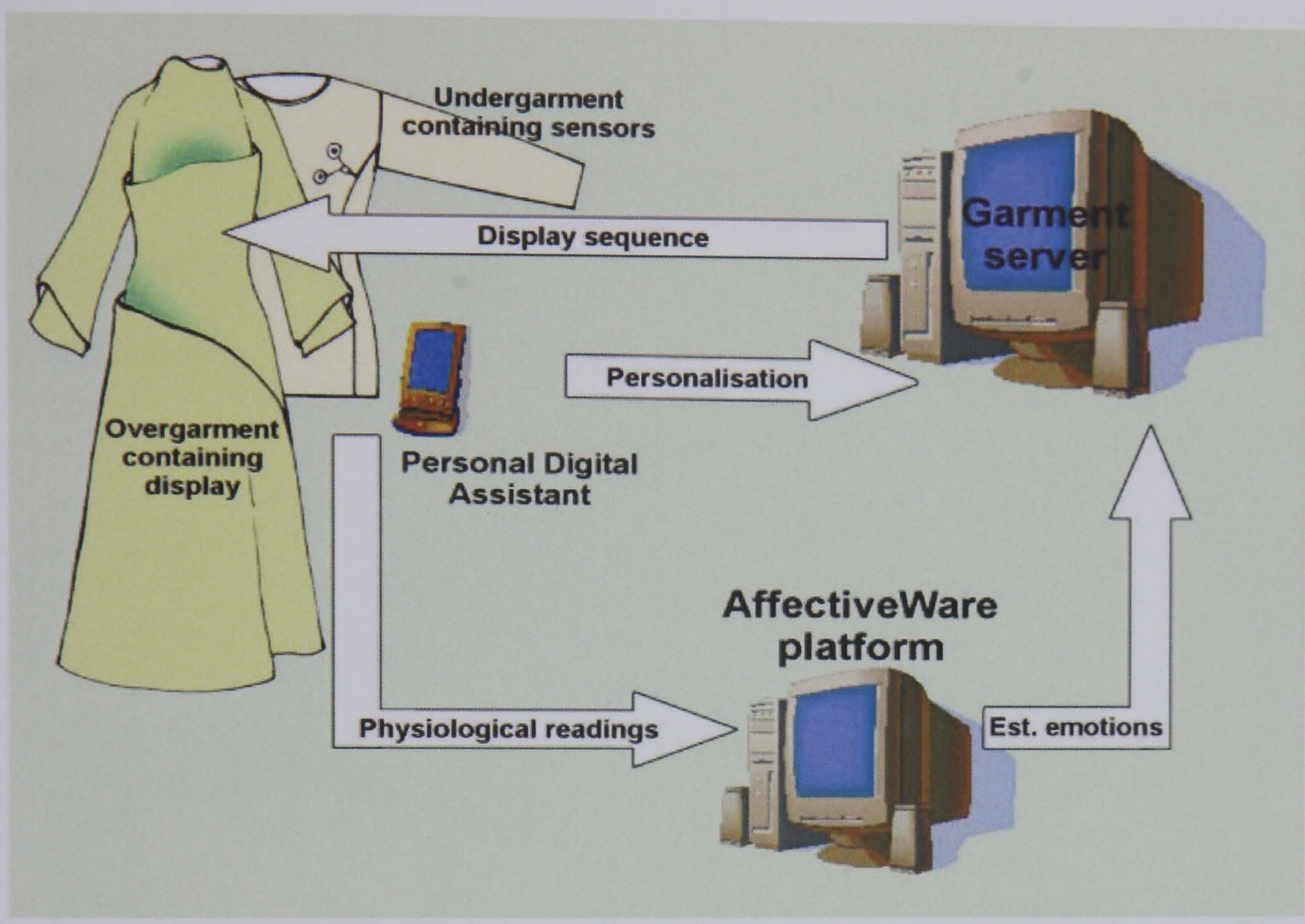


Fig.3. 52.
The data flow for Emovere.
Source: Lisa Stead.

Personal Sensor Network

The AffectiveSensors are built into a close fitting undergarment to provide maximum comfort for the wearer and to ensure unrestricted movement. Their positioning is shown (Fig. 3. 53). The AffectiveCoder is located in the small of the back to maximise comfort and to ensure that the aesthetics of the garment are not disrupted. The

AffectiveHeart sensors are located accordingly on the front of the undergarment. The AffectiveRings are also positioned on the left hand to minimise interference with the natural actions of the right-handed actress. This organisation of the Personal Sensor Network ensures that the technology is evenly distributed. The copper cables are covered with silicon insulation and are embedded within channels on the garment to provide extra comfort and to protect them from damage and breaking. The undergarment is made from a breathable and stretchable fabric to allow the skin to breathe normally and to avoid stimulation of sweat glands which could interfere with the affective readings.

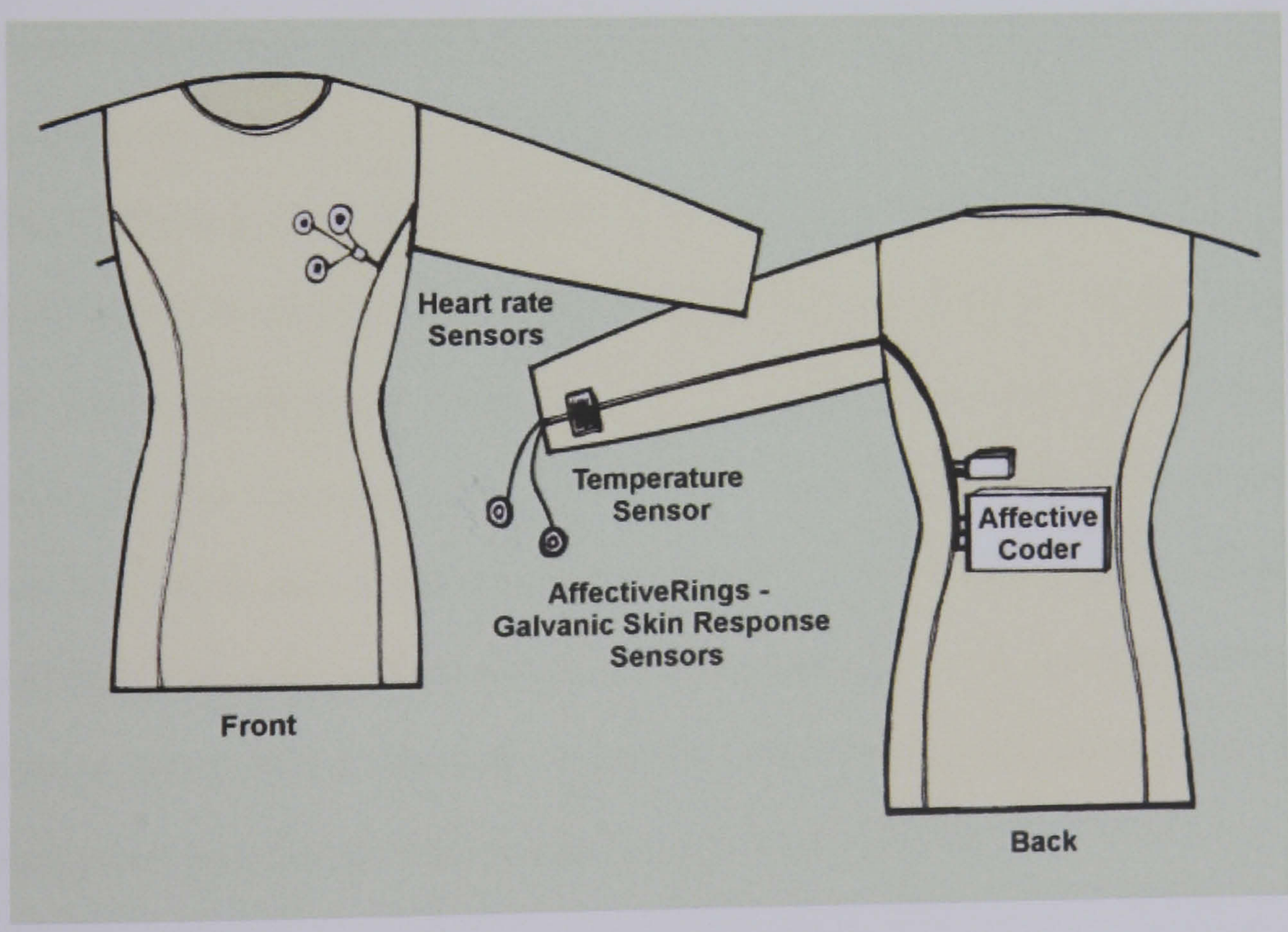


Fig.3. 53. The Personal Sensor Network.
Source: Lisa Stead.

EL to LED

At the end of the MA students project in June 2004, separate pieces of the system had been developed but they did not function as a whole. The model of the EL and inverter was not shining brightly so a decision was made to develop another source of lighting. Another student was employed over the summer period to create a LED and circuit board system. The LEDs were much easier to handle and provided sufficient light to create the effect of light seeping from behind the contours of the dress. And unlike the EL they did not require the felt to be rippled to carry the light which made the construction of the dress easier.

Garment Prototype

I produced a garment prototype by modelling wool felt on the stand to create the desired contours, building in a stiffened bodice to support the weight of the felt (Fig.3. 54). The LEDs and their wiring were hidden in the contours of the dress, stitched behind holes cut in the facing to allow the light to shine through. As the original felt material was considered to look too like a 'costume', I evaluated various fabric substitutes for their capacity to reveal the glow of the LEDs across the surface of the garment. The fabric also needed to be mouldable so that it could be modelled on the stand. Denim was even considered, as a replacement, with the garment darts utilized as a feature rather than an eyesore. Eventually the material that best met the needs of malleability and light transportation was found to be a wool felt.

Fig.3. 54.
A prototype of Emovere was constructed in wool felt due to its ability to be moulded and soften the light of the LEDs.
Source: Lisa Stead

Display Program

To enable the dress to be programmed, a piece of software analogous to musical scores was developed (Fig.3. 55). There are seven body zones where lighting is placed and these are represented by seven lines on the score. In each line, a colour (blue or green) can be selected by clicking on a box on the score. The length of the light signal can be determined by choosing a letter underneath the 'note' (a quarter beat to three beats). This is a very simple system that a child could use, and it makes the programming of the garment very easy. It also has a virtual illustration of the garment, which plays back the rhythm and placement of the lights, so that the program can be seen before it is entered into the dress. The program was used to translate the display rules into reality by triggering the LEDs in unison with the designed emotion pattern (see Unworn and Emovere Films CD to observe the eight programs working in the dress).

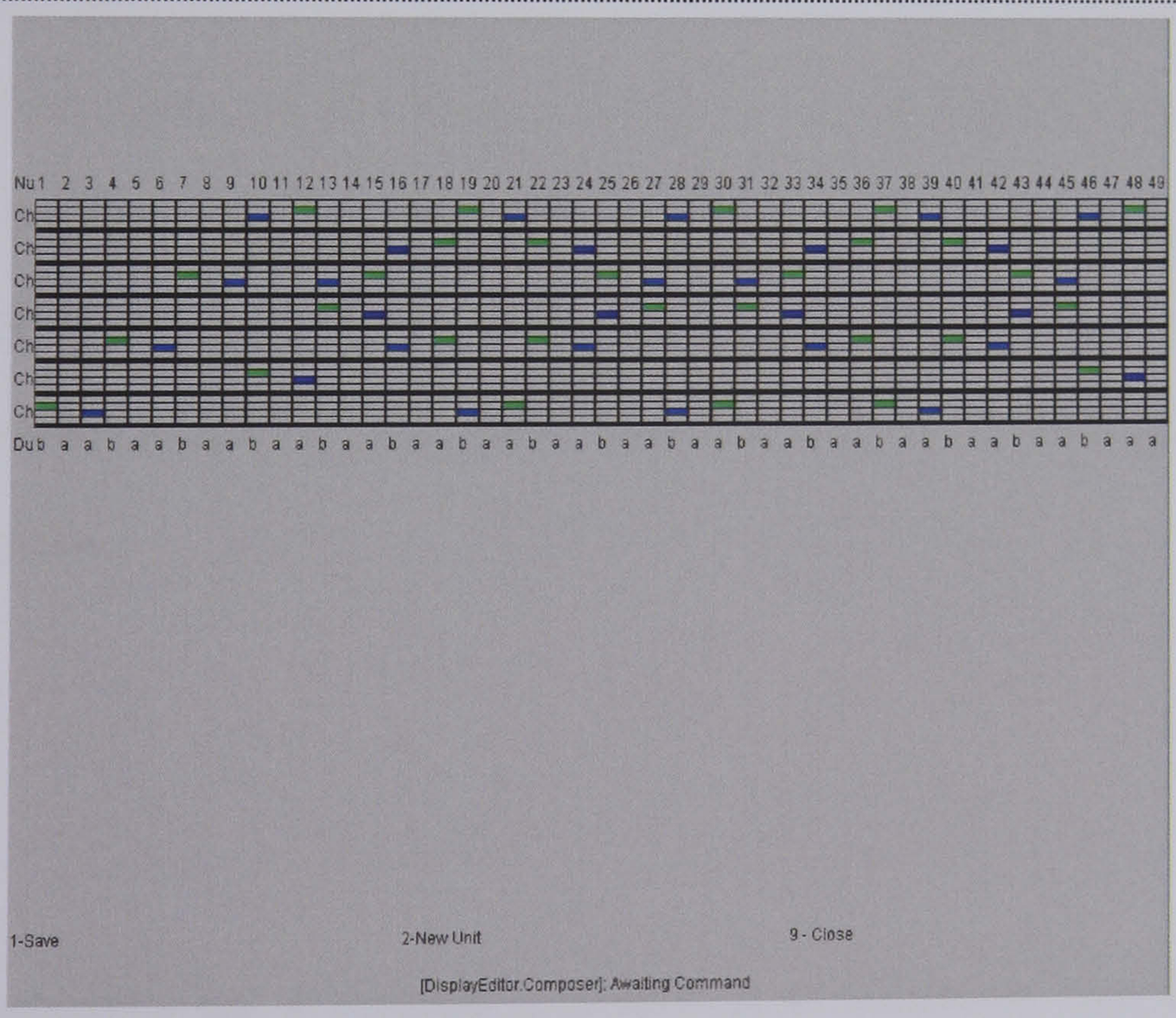


Fig.3. 55.
The interface for the display program has four main screens. First there is a general menu which provides access to the emotion chooser screen. Once the emotion has been chosen the emotion composer program can be entered. Once the display program has been designed, it can be replayed in the program visualization screen.
Source: Petar Goulev.

Steps To Completion

To tailor Emovere to the chosen actress a second set of readings were taken with her wearing the dress so that authentic data could be gathered. She again completed the same process of acting out the eight emotions. These readings were then analysed and used to create the rules of influence for fear and joy [200]. The actress was tested a third time to see if the rules of influence were working as planned.

At the point of submission (November 2005) the dress can demonstrate the theory although it is not quite finished in practice. All of the parts of the basic system have been integrated and work as a first prototype. Emovere reads and sends galvanic skin response readings wirelessly to a computer but the computer has to be set up manually by an operator to enable it to determine the emotion expressed by the corresponding physiological signal. The computer program automatically selects and sends the correct garment display program to the dress and the cycle of information is complete. To finish Emovere the rules of influence for all eight emotions need to be calculated and the mobile phone integrated into the system. This would allow Emovere to respond automatically to the eight emotions of the wearer without the intervention of a third party and the mobile phone would allow the wearer to have greater control of the display program.

Outcome

Emovere is successful as a concept garment as it illustrates that technology can respond to the body to aid the personalisation of a garment display. It demonstrates that it is possible, via the integration of affective computing and material technology, to

visualize emotions that have been enacted but it is too early in the research to prove that the emotions measured are correct. It is also a successful conversation piece to raise debate about the manipulation of emotions, the use of computers to read and respond to emotions, and generally the implication of putting technology on the body. However, it does not function as a truly wearable garment or as an everyday item of clothing as it is too cumbersome and strange by everyday standards. Wearabiltiy was sacrificed for the aesthetic aims of the design and the construction of the under garment could be much lighter and more flexible. Darts in its construction would have allowed a lighter fabric to be used and alleviated the need for a stiffened bodice. The lack of facing in turn would have required a different solution to diffuse the light. A further set of prototypes could be developed to apply the technology in a simpler and less obvious manner. Using the LED circuits in contours as developed for the dress, perhaps the light could be housed in epaulets, pockets or sleeve hems or used flat and covered by fabric overlays.

Another weakness in the development of the dress is that it is a first prototype, constructed as a final garment, which did not allow for the design to be better developed to house the technology. There were many problems with the integration of the technology and the selection of the dress fabric and construction methods could be improved but the extended development time of the technology meant that amendments were not possible. I had suggested to my collaborator that we should test all the technology together before integrating it into the garment but he was insistent that the lighting system should be stable and permanently embedded within the garment before the AffectiveCoder and platform was introduced. In my opinion this considerably slowed down the progress of the dress and did not allow for the dress

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[200] The rules of influence are the parameters that match the level of galvanic skin response to an emotion.

design to be developed in conjunction with the technology. I did not see the final system for the dress until towards the end of the process so this did not allow for any alterations and the technology had to be integrated in an ad hoc manner.

Ideally, aesthetic experimentation and technological integration should be developed at the same time so that one can adapt to the other. Where possible I would suggest that substitute models of the technology should be made that represent its size and weight but do not function. Although this would be partly speculative, it would enable the practitioner to continue developing the garment. This method was used to develop Emovere when access to the EL was impossible, and this process could have been extended to include the whole system. Although this would be costly and inefficient, it might solve problems of integration before they happen. Preferably, the technology would be developed before the garment so that the designer could design with it in mind. The prototype would be made and tested and further iterations of technology and garments developed, one adapting to the other, until a suitable outcome had been reached. Ultimately, technology would be produced to the specifications of the designer so that design would become foremost and technology becomes invisible.

A positive outcome of the development of Emovere is the new knowledge acquired about affective computing and emotional testing. My involvement in neuroscience research at University College London provided me with first hand experience of the problems of acquiring emotional data.[201] During my brain scans I was aware that when I was asked repeatedly to evoke a particular emotion such as sadness I also began to experience other emotions such as anger and impatience. I realized that the data

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[201] See P.A. Lewis and others, 'Brain Mechanisms for Mood Congruent Memory Facilitation', NeuroImage, (1 May 2005),p.p.1214-1223, for the study in which I took part to investigate the of impact of emotion on memory retrieval. The study was conducted at The Institute of Neurology,

scanned and analysed from my brain would not be completely accurate and muddied by the complex nature of emotions. This point was also emphasized during the emotional testing exercise that I designed for the 6 actresses. When they were asked to evoke a set of eight emotions many responded with the question 'what type of love?', 'acceptance?'. Research into emotions is still relatively young and there is no consensus as to whether basic emotions actually exist, or whether emotions are developed as evolutionary tools for survival or acquired in response to society and culture, or both. When a group of people is asked to evoke an emotion there is no way of telling whether they share the same definition of that emotion, whether it is a clear emotion or made up of a complex matrix of secondary emotions, and whether they will evoke or experience that emotion in the same capacity again in order to trigger the dress in the same way. There is no way of knowing this information accurately and this is the limitation of the technology. Nevertheless it has provided me with a means to express the concept of customisation via emotion interaction with the body. To truly produce an individual affective interface the wearer would have to be monitored in all contexts, both stationary and ambulatory, and in all temperatures, by a system that consistently learned from the wearer to uncover emerging patterns of emotions.

Implications

Emovere was a slow and time consuming process. It took two years to develop as a garment system. Although this was largely determined by the circumstances of the collaboration, it is a reminder that developments in wearable technology and in fashion can operate in very different time frames. From a personal perspective, the development of this garment has enabled me to participate in research at a deeper

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Wellcome Department of Imaging Neuroscience, London, See, <http://www.fil.ion.ucl.ac.uk/> [accessed 25 October 2005]

level that incorporates not only the design of the garment but also the development of aspects of the technology and the implementation of emotional testing.[202] It has given me a deeper understanding of the problems involved in the area of affective computing and the constraints of working within an academic institute. It has also given me an enthusiasm and confidence to continue research within the field of emotions, technology and clothing.

Socially, a garment that shows emotions might have major consequences in the work place, at home or leisure. It contravenes our learnt 'rules of display' and might mean that emotions are expressed at socially unacceptable times. However, this is the paradigm that Emovere seeks to challenge. It has been designed to provoke questions about emotions, technology, fashion and the future. It is an agent provocateur rather than a glimpse of the future.

[202] The emotion testing was carried out at Imperial College, London on 2 April 2004.

CHAPTER 4

Outcomes, Analysis & Evaluation

This chapter analyses and evaluates the research further looking at methodology, practice and knowledge base. Gray and Malins argue that analysis and evaluation work in two different ways: analysis seeks to understand the characteristics of the research, while evaluation critiques its value.[203] The work is analysed by reflecting on the structure and content of the outcomes to determine how they operate as individual case studies, and cross-referenced to show how they work together. The research methods and methodology are evaluated by their capacity to aid the research process and to move the work along in a preferred direction. The case studies are assessed by their contribution to garment construction, and aesthetic and technological understanding. The results are further evaluated against feedback following the work's dissemination, expanding upon the subjective understanding and experience of the practitioner. This information is used to identify the successes and limitations of the work.

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[203] Carole Grey and Julian Malins, *Visualizing Research: A Guide to the Research Process in Art and Design* (England: Ashgate Publishing Company, 2004), p. 123.

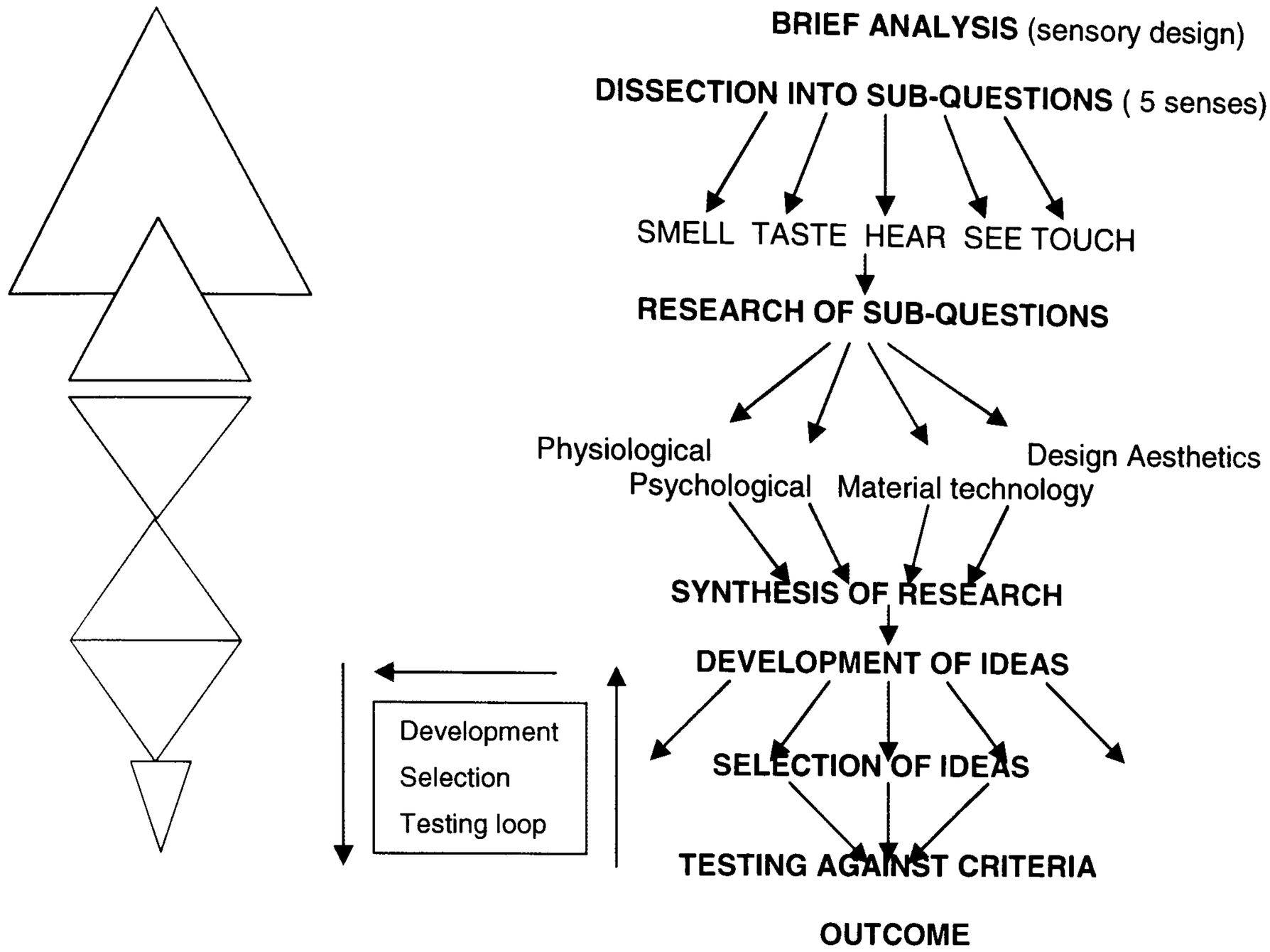
Analysis And Evaluation Of Methods And Methodology

This evaluation of the methodology refers back to the original strategy in the research proposal and contrasts it with the process that has emerged. It also discusses how the methodology was adapted to the needs of the research and uses this as criteria to judge its success.

The original statement of methodology indicates a systematic process of: **analysis** of the brief, **dissection** into sub questions, **research** of the sub questions, **synthesis** of research, **development** of design proposals and **selection** of designs by **testing** against the criteria (development, selection and testing is repeated until a suitable outcome is reached). The process shows a continual expansion and contraction of the question and its issues. (Fig.4. 1)

When this is compared to the methodology as defined in the Introduction, reflection is the one element not declared but suggested by the development, selection and testing loop, and the synthesis of research. The process does not show that the research process leads to the formulation of further research questions, which require further loops of development, selection and testing. This original diagram of methodology does however illustrate the information gathering stage of the process in more detail showing the research question as sub-questions which are researched and evaluated before they are brought to the development of ideas.

Fig. 4. 1. **Diagram Of Original Statement Of Methodology**



The research has shown that the integration of material technology has not changed the fashion design process but that it has lengthened. This is due partly to unfamiliarity with the technology and partly to the process of balancing garment construction techniques with aesthetics. In the traditional fashion design process, it is possible to be self-sufficient and to design and manufacture a garment without help. However, lacking technical knowledge I had to find collaborators such as Elumin8 to teach me how to work with the material technology, or such as Imperial College to implement the technology which again lengthened the design process.

The traditional fashion design process has proved sufficiently robust to accommodate other processes, such as the scientific approach of affective computing. In creative production the decisions and directions of research are based on tacit knowledge and can be explored and changed at the whim of the designer. In science the direction of

the project is governed by set parameters that the research uncovers and wishes to test. In this case the emotional testing and the readings provided the 'rules' to which the garment display would respond and so 'artistic' licence could not be employed. This information was integrated into the methodology as part of the information gathering phase but remained untested by the practice.

Also periods of problem solving necessary to implement the integration of technology have been absorbed as part of the material experiments and reflection process as shown in Emovere (see Micro View). When the EL was still attached to the bread board a substitute material was used in the dress toile and small swatches of fabrics used to mask the EL and evaluate the lighting effects (Fig.4. 2).[204] By addressing the characteristics of the EL (aesthetic and physical) independently, the problem was

Fig. 4. 2.
The EL panel was wired to the bread board during lighting technology developments at Imperial College. This made it difficult to handle the material.
Source: Lisa Stead

[204] A bread board is a temporary solution for the development of electrical circuits and systems. It provides a grid surface that electrical components can be plugged into and experimented with but is bulky and in this case required a mains power supply.

resolved and an overall representation produced. When the EL was changed to LEDs the original use of the technology within the garment remained the same, showing the practitioner can visualize the dress using substitute materials in the toile.

Methods

The methods employed in this project serve to visualize thoughts and make connections between pieces of unconnected research, to illustrate concepts, to test the information acquired in stages of the practice and to document the outcomes for reference and for reflection. Traditionally in fashion a theme board is used to bring together and illustrate relevant information, which then provides direction for a design or collection of designs. Throughout the research process theme boards have been used to map areas of interest and create visual stories for garment inspiration. Many of the theme boards were three-dimensional and visualized the body and its interaction with the environment, such as the Network and Molecular themeboards, as well as illustrating different characteristics of emotions, such as those used to inform the emotion experiments (Figs.4. 3 and 4. 4.).[205] Their tactile and tangible nature was especially important at the beginning of the research when due to technical constraints it was difficult to bring ideas to material fruition. Together the theme boards provided a visual overview of the research at the time and were used to provide an aide memoir of the issues as a reflective tool for the next stage of research.

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[205] The Network themeboard illustrates four themes, each represented by two arms of the frame: the body, technology, the environment and the dark-side of society. The first arm represents the themes as general groups i.e. the body as physiology, biology and alternative therapy, the second in more detail i.e. physiology as organs, biology as cells and alternative therapy as chakras. The theme board works by representing information down the arm of the frame and around the frame, so that the ideas can be cross-referenced and unclipped and changed as new connections are made. The Molecular theme board simplifies and reduces the concept of the body to three core areas of interest (physical body, sensory body and the body in the environment), expressed as three different aspects i.e. the body is represented physically as mind, body and emotion.

Fig. 4. 3.
The Network themeboard is made from an umbrella frame and magnetic images and operates as a semi-permanent, three dimensional information cycle that developed as the research progressed.
Source: Lisa Stead

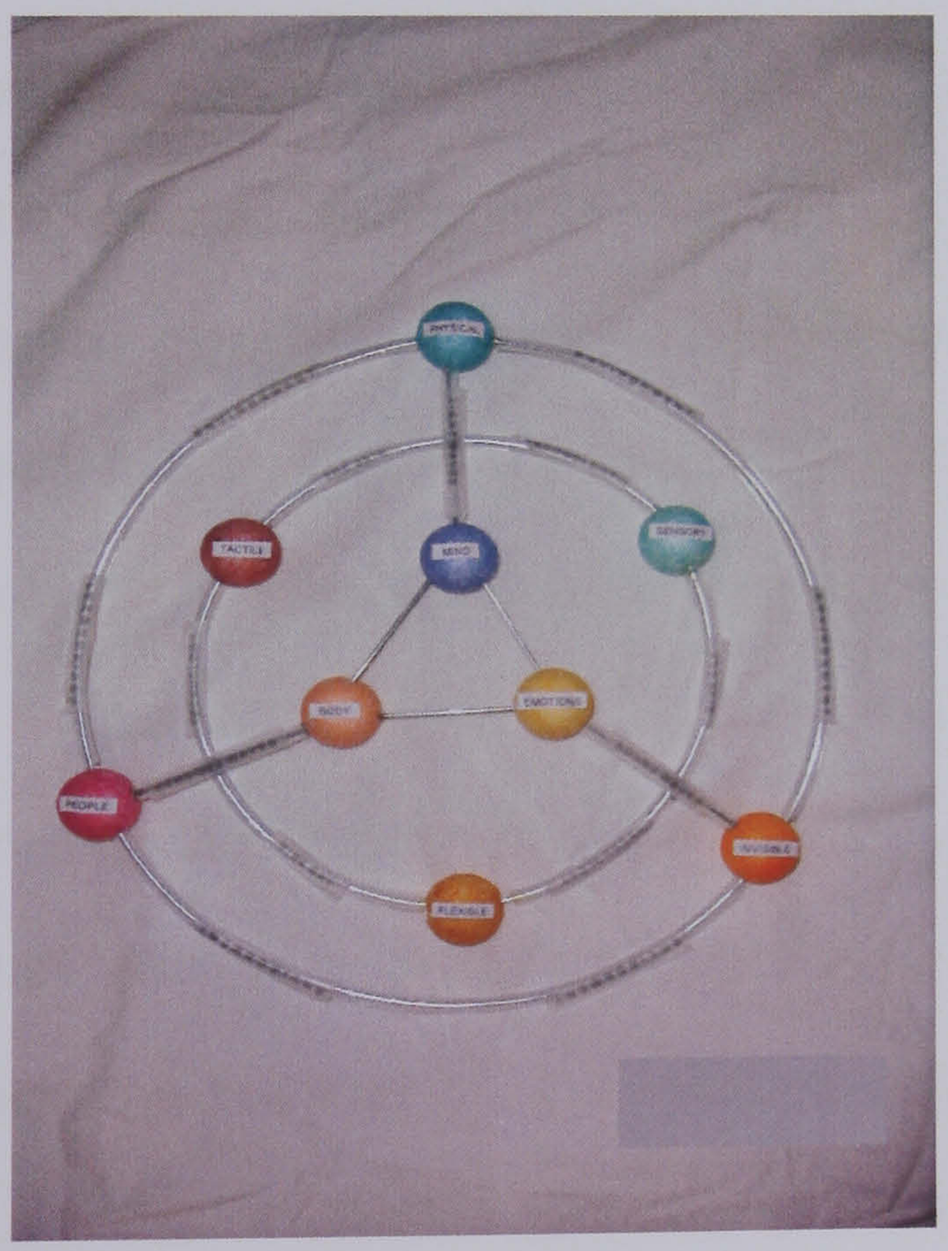

Fig. 4. 4.
Molecule theme board which represents the body as physical, sensory and environmental elements.
Source: Lisa Stead

The next stage of the research was to articulate the concepts that were emerging from the research and to incorporate the technology. This was done through a combination of modelling on the stand, toiling, computer generated illustrations, PowerPoint and film the methods building on each other and gradually creating more active representations of the ideas and visualizing the integration of technology.

Key to the development of the experiments and the case studies was modelling on the stand and toiling, fashion techniques that are used to trial garment designs or detail in calico before the finished garment is constructed. In the research, toiles and modelling were used for this purpose, as well as to experiment with ideas and to consider technical integration. Both methods largely replaced sketching in the design process, as it was considered more beneficial to handle fabrics to create three-dimensional shapes and ideas than struggle with two-dimensional renditions. When access to technology was impossible and progress was difficult they stimulated design-thinking acting to unblock the creative process. In this project the toiles had renewed importance, their function extending from generating garment aesthetics and fit to embedding technological functionality. This proved crucial in both making the garments aesthetically pleasing and in integrating the technology in an acceptable way.

Using Schön's terminology the process of toiling could be described as 'moves', in which ' Each individual move is a local experiment which contributes to the global experiment of reframing the problem'.[206] The toiles used here can be seen akin to scientific method, a process of addition and subtraction until the desired effect is achieved. At each stage the practitioner reflects upon and changes fit, shape and proportion and the aesthetic decisions rely on the practitioner's tacit knowledge, which

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[206] Donald A Schön, *The Reflective Practitioner: How Professionals Think in Action* (Great Britian: Arena, Ashgate Publishing, 1991), p. 94.

can be used to confirm or subvert accepted norms.

Computer generated illustrations worked as simple visualizations of ideas and as points for discussion with supervisors and peers, they also built on the ideas created in the Emotion Experiments by adding another layer to the photographs of the toiles. Photoshop was used to 'paint' the photographs illustrating the visual effects that technology could enable. Together with the toiles the illustrations helped to visualise technology enhanced garments without the necessity of technology.

Two PowerPoint presentations were developed for the exhibition which addressed each stage of the development of the concept and the integration of the technology (see Unworn and Emovere PowerPoint Presentations CD). They proved a useful tool showing the story of the research to exhibition visitors and attendees to my seminars. They were also influential in bringing different types of research together to clarify the design process and aid reflection. PowerPoint also helped to animate Emovere's display program illustrating unrealised technology and providing motion, an important

Fig. 4. 5.
A still of the film produced to show the concept of Emovere for the PhD exhibition.
Source: Stephanie Pau

factor in the visualisation of interactive technology. Next a film of Emovere was produced for the exhibition which added more detail and depth to the expression of the idea. The emotions were visualized by showing the wearer's emotion through body language and the corresponding display on the garment (Fig.4. 5). The film provided an overall vision of the concept in motion and acted as a substitute for the physical dress, which was still in development.

Outcomes And Comparisons Between Work

Different Forms Of Appraisal Of Practice

Evaluation of practice here takes a three-fold approach, which also illustrates different types of reflection. Firstly, the practice was evaluated as it was materialized, through devices such as toiles and observation, illustrating reflection in practice. Secondly, the practice was evaluated through the accumulated knowledge, a form of reflection after completion. Finally, it was evaluated through dissemination providing reflection by others, and this is cross-referenced with the practitioner's findings to offer insights into the strengths and weaknesses of the work and suggestions for improvements in future practice.

Operation And Evaluation Of Practice

The case studies build knowledge cumulatively in several areas and contribute to a growing framework of knowledge which is arranged in five areas: theoretical, aesthetic, garment construction, technical and garment response (Fig.4. 6.). The theoretical

position is the proposed concept of the work and the aesthetic knowledge is defined as the type of emotional communication that is expressed via the garment. Garment construction knowledge is the use of construction methods to aid the integration of technology and technical knowledge results from working with non-traditional materials (i.e.lighting technology, electronics and computation) and the ability to implement them independently or collaboratively. Finally, the garment response knowledge is the level of responsive technology employed. The case studies were constructed to build my understanding, with each case study emphasizing a particular aspect of the knowledge table. The evaluation addresses each knowledge area in turn and is based largely on the subjective opinion of the practitioner.

Theoretical Framework

Both the Unworn garments and Emovere were concerned with extending emotional communication and connection between garments, the body, culture and society, through the integration of technology. They focused on the use of traditional fabrics mixed with material, electronic and computing technology to enhance and challenge the aesthetic potential of clothing from a fashion perspective. The principle functions of the Unworn garments were to act as test beds for the integration of technology making technology more tactile and to create an emotional dialogue with the viewer through narrative and reactive garment displays.

Emovere aimed to increase emotional communication in a more literal way by using the emotional energy of the body to stimulate a change in aesthetics, made visible through the use of affective computing and material technology e.g. a raise in galvanic skin response might cause the dress to pulse bright green. Together these concepts sought

to extend fashion communication through dynamic emotional aesthetics; the Unworn drew on narrative and material technology and Emovere relied on the body and technology.

Knowledge Table

	THEORETICAL **The theoretical and contextual position to test**	AESTHETIC **The communication of emotion via design**	GARMENT CONSTRUCTION **The use of garment construction methods to enable technological integration**	TECHNICAL **The acquisition of technical knowledge and different forms of collaboration**	GARMENT RESPONSE **The use of technology to facilitate response**
Unworn	Traditionally, garments are static. Could technology be used to create dynamic aesthetics in garments? Could garments possess and utilize human traits and characteristics to become 'alive'.? Would garments expressing paradoxical emotions increase emotional connectivity with the viewer?	Garment shape, proportion, colour, fabrics and reactive material technology, inspired by body language and character narrative is used to enhance emotional and aesthetic communication. Pik Me - partial Icaris - successful Desiree - successful	Garment shape, construction and fabric is progressively considered to facilitate the invisible integration of material technology. Pik Me – not successful Desiree - partial Icaris - successful	Technical expertise in the capabilities of the material technology and its implementation is progressively acquired. Collaboration with an independent facilitator and an industrial partner. Pik Me - partial Icaris - partial Desiree - complete	Responsive technology is applied to the Unworn garments to trigger a change in the garment display. Pik Me – responds to sensor Desiree – responds to sensor Icaris – responds to sensor, touch and heat
Emovere	Could garment aesthetics be changeable through the use of technology? Could garment aesthetics reveal and communicate the 'inferred' emotions of the wearer? Could the display of the garment be programmed by the wearer?	Garment shape, proportion, colour and reactive technology, inspired by body language and music and emotion is used to enhance emotional and aesthetic communication. Inferred emotion but demonstrates the communication of human emotion via aesthetics.	Garment shape, construction and fabric is considered to facilitate the invisible integration of material technology. LEDs are invisible but the internal integration of technology could be reconsidered.	Technical expertise in the capabilities of EL and LED material technology, its implementation and the use of affective computing is progressively acquired. Collaboration with an academic institute.	Responsive technology is applied to the garment. It responds to the body signals of the wearer and their interaction with others. Garment display technology can be programmed by the wearer to respond to their emotions in different ways.

Fig. 4. 6. Table of knowledge showing: theoretical position, forms of aesthetic communication, levels of technological integration facilitated by garment construction methods, levels of technical expertise and technological response

Aesthetic Communication

Pik Me reflects the process of self harm to suggest sadness and loneliness but this would not be apparent without discussion with the practitioner. The overall aesthetic of the garment is designed to appear 'sad', due to its slumped posture but the 'veins', 'bruises' and 'cuts' provide a decorative rather than sombre aesthetic device. It could be said that the scarf looks sad but it arguable whether the technology helps to communicate the narrative without a written text. This is illustrated by the comment of a stranger who saw the scarf in its knitted state without the integration of the technology; she said that the scarf 'looked unhappy and very sorry for itself'.

Desiree builds on aesthetic communication by making more references to human traits and characteristics, associated with attraction, flirting and desire. The power of Desiree lies in the exploitation of recognisable fashion language, i.e. curvy = sexy, which is enhanced by a moving visual display. In the PhD exhibition, this combination drew the public to the garment, where they read the narrative text.[207] This added a second layer to the experience, through the suggestion that the viewer should compare their body in the mirror to the exaggerated proportions of the dress.

Icaris in comparison represents fear, but does not evoke fear in the viewer and is therefore a more complex representation of emotion. She represents the fear of flight, literally and metaphorically which is combined with the myth of Icarus to make a connection with heat, the loss of feathers and the ability to fly. The body language of fear is represented as a lack of motion but the narrative of the myth and the use of feathers enhance the aesthetic communication. Generally, Icaris has provoked the public to touch and physically interact with its feathers. It is enjoyed as both a tactile

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[207] Lisa Stead, 'The Emotional Wardrobe', Central Saint Martins College of Art And Design, 28 September - 1 October, 2004.

and visual experience in comparison to the other designs which cause only visual interest. Together the garment and the narrative could cause a paradox of emotions by eliciting empathy and sadness for her story but delight in her physical appearance.

Emovere is concerned with monitoring, expressing and eliciting actual, physical emotion, rather than implied as in the Unworn garments. In this way the aesthetic knowledge is expanded to include an interactive and dynamic element. The movement and rhythm of the display are modelled on body language and emotional characteristics of music but do not share any clear references to a particular emotional state or condition as in the Unworn garments. However, Emovere uses active but subtle light displays triggered by the body, to create intrigue and tension within the wearer and viewer.

The Unworn garments suggest that the communication of non-verbal human expressions of emotion and supporting narratives could be used to create emotional connection to 'empty' garments. Emovere directly communicates inferred emotion from the body and could enhance emotional connection of others to the wearer. Although there is a distinction between the narrative devices and affective computing methods used to evoke response in the viewer the effectiveness of either method has not been formally tested and could be considered as an area for future research.

Integration of Technology

Each case study employs a different approach with regard the integration of technology which is driven by the chosen technology and garment narrative. In Pik Me the integration of material technology is partial and woven simply into the surrounding knit

structure. Desiree shows a greater integration of the technology, although it is still covered by fabric rather than being part of it. Icaris is the most integrated garment as the dyed feathers form the fabrication of the garment which do not require any construction technique other than would ordinarily be used for stitching them upon a garment. However, the heat pads that trigger the colour transformation of the feathers require an additional layer of fabric within the jacket to support them and their wiring, although this is largely invisible to the viewer within an exhibition situation. Emovere is less successful than Icaris in its integration of technology. It does use garment construction techniques to hide the technology, in this case a contour device to house the lighting system, but the technology is still an add on, and the inside of the garment could be reconsidered as a device to support the technology. It does however build on the integration of technology in another way by focusing on the use of light. Pik Me and Desiree concentrate on the flat integration of light which simply glows through the fabric. Emovere uses lighting technology as a three dimensional aesthetic device by embedding LEDs into the garment to reflect coloured light and create shading to add dimension.

Acquisition Of Technical Knowledge And Collaboration

The accumulation of technical knowledge in the case studies show different levels of my technological understanding and implementation. For both Pik Me and Icaris my role was to develop the aesthetic and narrative concepts. I experimented with EL wire and thermochromic inks to assess their use. However, I was unable to implement the sensors and the heat pads or program the timing in Pik Me or Icaris. To counteract my lack of expertise in these areas, I worked with an independent paid facilitator, Ben Sheehan. This was the easiest form of working with others in this project. Paying for

technical assistance enables the nature of the outcome and the time frame to be agreed. A paid facilitator is ideal, when technical knowledge prevents the practitioner from carrying out the work themselves and a tighter time frame is necessary. The downside of this approach is that there is less learning and additional costs but the working relationship is defined and straightforward. This approach was a useful first step in realizing ideas with technology.

The aim for the Desiree study was to understand and facilitate the complete technology and garment process. I can solder and insulate the lamps and program the sequencing chip for the inverter, completing the technology for the dress. Working with an industrial partner, Elumin8 enabled me to be mainly self sufficient, learning under the guidance of a technical advisor which proved very straightforward and allowed me to retain autonomy. The difficulty of this way of working was that I was restricted to the basic use of the technology and by my basic knowledge of the materials and processes, which resulted in a simple integration of the technology within the Desiree garment. However, this way of working provided a basis of knowledge to build upon and offered a successful and empowering way of working.

For Emovere I was again in the role of a garment and concept designer with Imperial College providing the technology. As a result my technical knowledge has increased very little. However, I have engaged with the subject of affective computing on a deeper level of knowledge than in the other three garments, therefore building on my technical knowledge of another discipline. I planned and implemented the emotional testing exercise with the six actresses and helped evaluate the outcomes. The testing enabled me to uncover the complexity of emotional categorization and its implication for the validity of the method to attribute physiological signals to emotions.

The work with Imperial was rather ad hoc and the project was largely at the mercy of others. My exploration of the EL materials was also restricted as I waited for the relevant inverter to be developed. After initial developments by MA students, the remainder of the technology development was taken on by an enthusiastic but overworked part-time PhD student who had to make time to work on the project. I have felt grateful for receiving my collaborators enthusiasm and support but at times I have not had an equal share of the power to push the project along in my own direction and time frame.

Also, electrical engineering methodology is more prescriptive and determined by a problem solving approach. They wanted a problem to solve; I wanted to experiment to find the problem. Initially, it was also difficult to find a shared language and agenda, which required time and perseverance. Positively, the discussion of the project uncovered the light score analogy used in the design and programming of Emovere display. It created an understanding of ideas i.e. light pulses as rhythm and the software program layout as a score and it also took my research into a different area of music and emotion, widening my knowledge.

Although the experience of working with another academic institute proved complicated at times I was rewarded by a greater understanding of the issues of working with others and a deeper knowledge of affective computing. Ideally, I would suggest that research with other academic institutions is supported by an official agreement or is carried out within the remit of a funded research proposal, where the members of the team can focus on the aims, objectives and timeframe of the project.

Garment Response

The case studies very simply and clearly build on the possibilities of technology responding to the body. Pik Me, Desiree and Icaris are responsive garments that react to the presence of the viewer via proximity sensors. Icaris can also react to body, ambient or environmental temperatures without the aid of electronic technology showing the next level of reaction. Emovere extends the potential of wearer response, by enabling the technology to respond to multiple changes in the physiological body, arguably caused by changes in the psychological state of the wearer. Emovere creates a dialogue between the wearer's emotional state, the dress and the viewer, generating a responsive cycle. The next level of interaction would be to develop a dress that learns from the wearer in everyday contexts. The wearer could 'teach' the garment by revealing personal traits of emotional behaviour, in common situations. By measuring, storing and evaluating these changes over time, the dress could compare results to context and then decide whether it is beneficial for an aesthetic change to occur.

The knowledge table acts as a method to compare and contrast the case studies against a set criteria determined and assessed by the practitioner. By expanding the evaluation of the case studies to consider the reaction of peers and the public, the practice is set in a wider context of evaluation and appreciation.

Dissemination As An Appraisal Device

The dissemination of practice operates as a voice for the research in the academic and public domain, raising awareness of the specific research issues addressed in this study and heightening recognition of the area of fashion and technology. It also acts as

an evaluation tool by stimulating response in others and generating debate about the work. Feedback has been informal through discussions after presentations at conferences, and personal feedback from peers and professionals working in the field. Exhibitions have also exposed the research to a broader audience, while peer reviewed journals have given a more formal appraisal. The findings of dissemination are explored in the following section.

Emovere – Visualising Emotions

Emovere and its emotional context have generated many responses positive and negative. It has been disseminated thorough two peer reviewed papers, a conference paper, an academic seminar and radio interview, and with the Unworn garments as part of 'The Emotional Wardrobe' at public seminars and exhibitions. Reaction from academia and the public has been positive although those who see the visualisation of personal expression as worrying view Emovere with some suspicion.

Emovere was presented as a peer reviewed paper at the 2AD Conference in 2004 at HP labs in Bristol, where I was asked, 'as evolution has developed ways to show emotions over many hundreds of years why would we need a dress to do this for us?'[208] Others expressed fear of wearing a garment that could express emotions. These points together create a dichotomy. If we accept that evolution has given us the skills to communicate our emotions through non-verbal signs anyway why would we be frightened of a dress that replicates this function? The dichotomy is explained when we

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[208] Lisa Stead, and others, 'The Emotional Wardrobe'. *2AD The Second International Conference on Appliance Design*, (May 2004), 126-132. This paper was also published as Lisa Stead, and others, 'The Emotional Wardrobe', *Personal and Ubiquitous Computing*, 8 (2004), 282-290.

see that we mediate our emotions constantly throughout the day.[209] This is further supported by the notion of voluntary and non-voluntary emotions, or those that we can control and those that are automatic.[210] We clearly do not always tell the truth through our body language and can not always control our emotions. Emovere seeks to catalyse a debate on this topic, proposing that a dress that always told the truth would be a 'dark' and interesting concept.

Emovere has also been met with a positive response in the most unlikely manner. During the discussion after my seminar at 'Dressing With Attitude', in Henley it was the most loudly dressed and extrovert lady present who expressed a fear of the garment, as she did not want to expose herself to the scrutiny of her peers. In contrast, a self-confessed introvert thought that the Worn dress was a welcome antidote to her self-conscious personality. She hoped it would be a way of her gaining attention without having to be loud or vicarious.[211]

Emovere – Is It Valuable?

At the 'Dressing With Attitude' seminar the lively discussion ended with the question of how to apply the technology in other areas. I talked about the possibility of using the AffectiveWear platform within a garment for therapeutic affect, either as a communication tool for stroke victims or as a learning tool for autistic children (see Recommendations for future research). For many, this provided an application for the

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[209] David Livingstone Smith, 'Natural Born Liars', *Scientific American: Mind*, 16, No 2 (2005), 16-21.

[210] Le Doux discusses the difference between involuntary emotions that are predetermined by evolution and the wilful control of emotions using cognitive functions to assess the most appropriate emotional reaction to a situation. He calls this a 'shift from reaction to action.' See Joseph LeDoux, *The Emotional Brain: The Mysterious Underpinnings of Emotional Life* (London: Phoenix, 1999), p. 175.

[211] The 'Dressing With Attitude' seminar was held in Henley-on-Thames, in November 2004.

technology that they could understand and see the worth in developing which was a common response among my various audiences. This concern was also raised during my seminar at University College London Computing Department.[212] The seminar was for staff and doctoral students and many present were from the discipline of Human Computer Interaction, which seeks to improve usability in human computer interfaces through aesthetics and the norms of human behaviour. Their studies are function-focused and it was difficult for them to appreciate the value of applying technology to a fashion garment for purely aesthetic purpose without the aesthetics enhancing technical function. However, as the technical function of the dress is to aid communication and the dress is an interface to the integrated technology as well as the outside world perhaps the two pursuits are not so dissimilar. At 2AD a member of the Vodaphone research and development team also said that it would be interesting to evaluate Emovere to see if it had any added value. This is the struggle that the fashion technology merger needs to address by developing technology enhanced garments that do have a perceived worth. This could be attained through user studies i.e. giving the garments to volunteers to wear and evaluate before they are manufactured as a product. Alternatively, the technology could be used in a functional garment that creates an acceptance of the technology for a functional purpose before its application in a fashion garment (see Recommendations For Future Research).

Aesthetic Acceptability

Building on the idea of perceived worth is also the aesthetic appeal of the garments. At 2AD one participant from America, who was developing the idea of interactive furniture, commented that Emovere was the most poetic use of lighting technology that he had

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[212] The seminar was held at University College London, UCLIC, April 2004.

seen. When I presented Emovere at a radio interview at the BBC World Service the response was mixed. The interviewer enjoyed the concept of Emovere but she could not see the look of the dress being accepted as an everyday garment.[213] Again, during my PhD exhibition I was aware that there was an uneasy balance of aesthetics and technological function. By situating the exhibition in a fashion department at a world-renowned college of art and design my work was assessed by the same aesthetic criteria as any other fashion garment within the department, and there were no allowances made for the difficulties of integrating technology within the garments.

The location and look of the work has repercussions for acceptance by the fashion community, who may not engage with the narrative or conceptual choices but instead judge the aesthetics by the same criteria that they would apply to a finished fashion garment without technology. It is a fine balance, which Hussein Chalayan appears to have conquered due to his reputation as a conceptual designer who also manufactures and sells. He uses technology to serve the realisation of his ideas, which provide centrepieces for his catwalk shows. Even though his forays into a fashion/technology merger have resulted in 'otherworldly' garments their aesthetic or fashion credentials are not challenged, as people know the difference between a showpiece and a selling collection.

My aims are different as I am working in research and, although I am interested in the expression of ideas through technology, I am also concerned with understanding the technology and mapping out new territory for fashion and technology. This requires a change in emphasis and a willingness to borrow methods and approaches until they can be integrated as a normal part of the fashion design process. It is questionable that the fashion industry's attitude to technology in garments will change but the standards

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[213] Go Digital, BBC World Service, June 2004.

by which they judge the aesthetics of technology enhanced garments can be seen as positive. As our aesthetic knowledge of garments is largely determined by the fashion industry, then technology-enhanced garments must meet these standards. In many ways it is more necessary to support the added costs and unfamiliarity of technology with the aesthetic and construction values of fashion, for it to become acceptable and desirable. This does however raise the question, is my work fashion?

Is It Fashion?

Fashion is used to communicate all nuances of identity and as such can be seen as a tool to experiment with identity. This results in ambiguity and ambivalence and it could be said that Emovere plays with both of these qualities. It acts as a trial of identities, allowing the outward communication of self to be manipulated, and plays on the contradictions of fashion whereby the wearer experiences both pleasant and uneasy emotions. If fashion is defined by its speed as well as the communication of self through style, then the slower development time of Emovere and the Unworn garments might not initially be considered fashion. From a different point of view, the use of responsive and programmable display technologies could represent rapid change in a single garment rather than rapid change characterised by a cycle of mass consumption and obsolescence. In this context the garments are a comment on contemporary fashion – a part of fashion but separate from it, a way of looking at how else things might be done. There is no clear answer to the question of whether my garments are fashion. However it is worth remembering that Emovere and the Unworn garments are early-stage academic prototypes rather than finished garments ready for sale and that it is normal to expect research to take years to translate to commodity. People are not ordinarily exposed to the development stages of products, only to finished garments

hanging in a shop so their judgements and acceptance are governed by the usual ways that they consume. Therefore it is difficult to realistically assess the work outside of a research environment. The most useful answer to this question is the definition given by Simon Thorogood:

> I would say that what I do is fashion, I wouldn't say that it was fashionable, but I would say that to belongs to a world of fashion and a world of movement and a world of clothes.[214]

Overall Reflections On Dissemination

Overall The Emotional Wardrobe concept has met with interest and I have been encouraged by the response of the public, peers, students and the technology industry. For some, the Unworn garments are the most powerful part of the concept development. They are easier to understand in terms of technology, look and concept. Desiree is always mentioned in seminar discussions after the talk, as the idea of a flirting dress is one that people can readily identify with and see as a garment in everyday life (conceptually rather than aesthetically). Icaris has a tactile appeal, which draws audiences to touch the feathers; when the feathers change colour the garment engages their interest further as they wish to know what the technology is and how it works. However the dissemination of the work did not prove that the garment characters had persuaded the public or the narratives enhanced their emotional experience. Emotional response to objects, experiences or people is notoriously difficult to assess (as shown in the work of Le Doux, Damasio and Pieter Desmet, see the Context Review) but future work could include an evaluation. The Unworn garments could be presented without their narratives and viewers asked to guess the emotions or characteristics the garments express.

As a concept Emovere is more difficult to understand but in instances where I have had time to explain the technology and the thinking thoroughly, it has caused the most discussion and debate. Although some people are still concerned about a garment showing their emotions, they are more relaxed when they understand that the wearer can control the display and that the display sequence is abstract. They are also reassured that possible dubious uses of affective computing can also be counteracted by its potential therapeutic uses.

The technology field has embraced my ideas, as part of the drive to make technology more emotional. This can be shown in the formal acceptance and evaluation of the Computer Aided Emotional Fashion paper written with my technology facilitator at Imperial College.[215] The Emovere concept was peer reviewed for the journal *Computers and Graphics*. The paper was rated as a 3-4 standard, which included the comments that it is 'a pioneering piece of work', 'one step ahead of the pack' and 'definitely relevant' to the special edition of the journal on pervasive computing and ambient intelligence. I have also received informal feedback from The Research and Development Departments at Kodak, Phillips and Vodaphone who have all expressed an interest in the work and noted its significance in progressing the emotion, technology and fashion agenda. This is evidence that the work crosses boundaries but also that it is the technology sector that appreciates that fashion could provide a means to make technology wearable and "wantable". In contrast it appears that the general public needs to be presented with a finished product that is wearable, and looks ordinary so that the technology can be easier to accept. The fashion industry has many practicalities for the electronics industry to overcome before the potential of

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[214] Interview with the designer, Simon Thorogood, London, 2004.
[215] Goulev, P and Stead, L. 'Computer Aided Emotional Fashion', *Computers and Graphics*, 28 (2004), 657-666.

wearable technology becomes apparent and interesting but it will also demand aesthetic and construction standards that are equal to garments without technological enhancement.

Success Of Practice – Work As Debate And Dialogue

The success of the work is its ability to create a dialogue with people that it encounters. Whether their reactions are positive or negative the work has the strength to generate discussion. By borrowing the analogy of a dialogue or conversation the practice can also be seen as a series of successful conversations between the materials and myself, the garment and the wearer, and the viewer of either the Unworn or Emovere.

By giving the work a paradoxical emotional context, the garments have been designed to stimulate debate about the use of emotions and technology in garments, the emotional context of technology today and possible repercussions in the future. Emovere has provided a standpoint to discuss the engineering of emotions, emotional dissonance and neuromarketing. It has generated discussion about affective computing and the measuring of emotions and provoked discussion as to whether we would want technology on the body in the first place.

In *Hertzian Tales* Anthony Dunne views his work in a similar way to The Emotional Wardrobe, in that he offers ideas and the space to contemplate their meaning through dissemination. He writes that 'they [his work] ask questions rather than provide answers and should stimulate discussion in the way a film or novel might.'[216] The Emotional Wardrobe does not provide answers to the issues it reveals but stimulates

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[216] Anthony Dunne, Hertzian Tales p 92

debate and discussion, to use another phrase borrowed from Dunne, they 'make visible the invisible'. Pieter Desmet refers to Fridja and Schram to illustrate the potential of mixed emotions, observing that 'art often elicits paradoxical emotions, and that it is precisely these paradoxical emotions that we seek and enjoy'.[217] By this rationale the provocation of mixed emotions should provide a stimulating and pleasurable experience and this has been the atmosphere in The Emotional Wardrobe seminars that I have conducted.

The industrial designer Gaetano Pesce is interested in the concept of objects 'carrying meaning'. In Pik Me it was my intention that the scarf denoted emotional meaning and carries with it a document of its 'harmed' history. Pesce classifies his work as 'furniture disguised as art or vice versa' and makes an interesting point that 'art was always a functional product' such as a portrait or a product only later did it become 'art'. By this rationale, he describes the 'art of our time' as being clothing, advertising and objects.[218] Similarly, my work could be seen as stimulating reflection and dialogue in the viewer, in parallel to the perception of art. I am not however claiming that The Emotional Wardrobe is art, simply that it has some of the same polemical characteristics through its narrative elements and its use of technology.

Emovere uses the analogy of a conversation or dialogue to explain the process of interaction between the wearer, the technology, the garment and the viewer. The interaction of the wearer with the dress and the technology is a cyclical process stimulated by the emotional state of the wearer. This conversation could be interrupted by the addition of a viewer, involved in either a spoken or silent communication with the wearer. This could subconsciously cause a change in the emotional state of the wearer

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[217] Pieter Desmet, pg191
[218] Justin Mc Guirk, 'Gaetano Pesce', *Icon*, September 2004, pp. 45-46.

and change the course of the various threads of conversation. In this way, Emovere creates a dialogue between the body, technology and the wearer and viewer.

I have also found that the case studies work as a series of conversations with the materials and myself. From a subjective perspective, the process of toiling provided a reflective conversation with the materials, form, structure and intent of the garments. Within the case studies, the material experiments also created a silent dialogue between the practitioner and the traditional fashion fabrics. A dialogue or conversation implies that there is an exchange of information between at least two parties and that one party will remain silent in order to hear the perspective of the other. In both cases, the reflective process acts as the 'silence', a process that Maria Blaisse in a lecture at The London College of Fashion called simply 'observing the materials'.[219] Through observation and reflection the material and the toiles 'talk' to inform the designs.

The garments contained within The Emotional Wardrobe operate as different 'conversational' pieces to stimulate the research process. They create an interface with social and cultural issues of the day and the practitioner and raise debate and speculation amongst the participants of the seminars. Through reflective contemplation they also inform the direction of garment developments.

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[219] Maria Blaisse gave a lecture on her work called, 'Flexible Design', at The London College of Fashion on 24 October 2002.

Difficulties And Suggestions

The research process has uncovered many difficulties when attempting to work across the disciplines of fashion and technology. Some of these are practical such as access and availability of the required technology and some are caused by the different approach required by balancing problem solving skills and creative production skills to attain a balance of technology and creativity. The necessity of working with others has also proved difficult and rewarding in equal measures and emphasized the contrasting working practices of the fashion and electrical engineering approach and the need to devise a common language of communication.

Access To Technology

It became clear over the course of the research project that that chasing less accessible material technology such as printable EL can prove unfruitful and time consuming. A decision was made to use accessible colour change technology in its most basic form, such as EL panels, wire, LEDs and theromochromic inks. This decision refocused attention on ideas, enabling the work to be concept driven rather than concentrating on advanced forms of material technology. Even though the integration of the materials in their most basic form posed problems I believe their use strengthened the consideration of concept and context. This view is supported in the PhD thesis of Sompit Moi Fusakul (Practice Review). She too was forced to use very common and accessible material technology but states that, ‘we don’t always have to use something completely new to create something that is ahead of time in its concept.’

To overcome these problems I chose accessible technology and returned to the fashion design process to visualise ideas through sketching, PowerPoint and experimentation with shape on the stand. The case studies show that toiling and construction techniques can provide solutions to the integration of technology. The case studies show technology added into garments rather than being an integral part of the garment. However for first prototypes they offer methods to make ideas concrete.

Environment

Working within a fashion environment has also created problems as I have attempted to address technical issues without the know-how being available within the institute. This has meant that I have been forced to seek outside help, which has proved beneficial, but not time efficient. The project could have been conducted within a technical institution where access to technology and assistance would have been easier but it might have resulted in a compromise of conceptual or aesthetic considerations in favour of technological advancement. I also think that it is important to carry out research within the environment that needs the most exposure to its results, to aid knowledge and idea transfer. I believe that fashion students should be made aware of the existence of wearable technology and its potential, even if they later dismiss its importance. In this project working with technology within an art and design college has proved difficult but has been overcome by creating a network of technological facilitators as mentioned above and by turning these difficulties into positives the project gains its strength. The research has charted new territory and found solutions from working inside rather than outside a fashion institute.

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[220] Sompit Moi Fusakul, Chapter 5, p20.

CHAPTER 5

Summary & Conclusions

Extent To Which The Objectives Were Met

The four objectives of the research project were largely met. The first objective, to develop working prototypes was evidenced in the case studies. Case study experimentation combined sensors, colour-change materials and affective computing with traditional fabrics to create a series of changing displays. The display systems provided the foundation for the garment prototypes which all responded to human stimuli in the desired manner.

The second objective was to investigate the impact of technology on the fashion design process. The research achieved this aim by following a traditional fashion process to investigate and integrate material and electronic technology in garments. Using material technology with its wires and electrical components, did present complications but fashion methods such as toiling and seaming were used to solve the problems. Occasionally a deviation of the process was required, such as learning to solder EL panels but the new knowledge 'created' the material technology which was then integrated in a traditional manner. In this way the research demonstrated that the fashion design process could successfully accommodate technology if additional time is allowed.

The third aim was to work collaboratively between the fields of fashion, computing, electronics and material science. The technical nature of the research made collaboration a necessity. The research shows three ways of working in this field: with

an independent advisor, with industry and with academia and therefore offers three different perspectives on the collaborative process.

The fourth and final objective was to alter the definition of fashion communication by creating responsive aesthetics that communicate and elicit emotions. Future cultural change was also to be addressed. This project successfully fulfilled the objective by adding another responsive and emotional layer of communication to fashion via colour-change and sensing technology. Both the Unworn garments and Emovere respond to dark future scenarios and seek to communicate and provoke emotional response. Although this element of the objective cannot be proved scientifically, the work asks important questions about the development and use of technology to engineer, mediate and measure our emotions as well as the future of fashion and technology. It is hoped that others will continue the debate.

Original Contribution To knowledge

The original contributions to knowledge comprise of the integration of technology and fashion to enhance communication, thereby extending the capacity of fashion to communicate. The use of affective computing, sensors and material technology situates fashion in a new cross-disciplinary area. By crossing borders, the work is able to contribute to several fields: fashion, electrical engineering, emotion research and affective computing and interaction design. The notation and articulation of the fashion design process also clarifies fashion design methodology for use by other practitioners.

Methodology

A proportion of my original contribution to knowledge is the articulation, explanation and documentation of my process as methodology. In fashion design methodology is rarely discussed. There are no academic publications that specifically deal with fashion methodology in the same way that it is addressed and analysed in other fields.[221] One of the few references to fashion methodology emanates from a research project at The Royal College of Art that investigated the fashion design process and produced a software package supporting a database of contextual information for fashion designers.[222] The research did not aim to clarify fashion design methodology so much as provide a tool to aid designers.

As the designer Simon Thorogood states, 'fashion design is a process that has been conducted in much the same way for hundreds of years.'[223] Although, methodology is inherent to fashion design as it is taught in higher education it is not identified as separate from the design process. A student of fashion design will be taught to follow a process of information finding, selection, abstraction and application based on a set brief. This is the accepted way of working within industry and academia. Both sectors governed by the criteria of commerce and creativity. It is my hope that the methodology outlined in this thesis will act as a tool for other practitioners. Further, based on the assumption that one first needs to understand a process before one can change or subvert it, it may encourage others to alter the process in a meaningful and conscious way.

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[221] Although there are many books on fashion design process such as, Sue Jenkin Jones, *Fashion Design* (London : Laurence King, 2002). See Nigel Cross, *Engineering Design Methods: Strategies for Product Design*, 3rd edn (Chichester, Wiley, 2000) for an example of methodology articulated in another discipline.

[222] Gillian Crampton Smith and others, 'Designing a Database for Fashion Designers', *Conference on Human factors in Computing Systems*, (1993) 49-50.

Extending Fashion Communication

The Unworn garments demonstrate ways of using technology embedded in garments to communicate in different ways to normal clothing, such as through changing surface colour in response to a viewer. They use technology in a playful and creative way, suggesting that a dress could flirt with the viewer through a 'winking' display, or a scarf attempt to grab the viewer's attention and sympathy by its showing its pain as she/he approaches. By creating conversations with the viewer in the domestic environment the Unworn garments imply that garments have life away from the body.

Emovere suggests that body signals can be used to trigger another layer of garment communication responding visually to the mood of the wearer. This concept plays with the idea of revealing private emotions. The garment raised the question that a wearer might therefore choose to wilfully manage their emotions rather than let the dress reveal their unguarded feelings. In this way, the emotional element of identity and personality is converted into changing aesthetic display. The idea of communication is further confused for the viewer by the use of abstract display patterns; for example anger is not represented as red but as a combination of rhythmic blue and green lights moving around the body.[224] In an annoying situation, where it is socially unacceptable to articulate one's feelings, Emovere might enable the wearer to subtly vent their rage without detection. This implies that fashion could communicate the complexity of human emotions and the changing nature of identity in an immediate and spontaneous way. This extension of fashion communication in Emovere and Unworn garments replaces the fixed physicality of fashion with a constant flux of self-expression and playful psychological experience.

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[223] Interview with Simon Thorogood, Waterloo, London, 2004.
[224] The use of colour in Emovere does not draw on recognised colour semiotic symbolism but is used instead to portray 'note' intensity i.e. the green LED is visually brighter than the blue and is used to signify 'louder' (music and) emotion phrases.

The Unworn and Emovere case studies show varying degrees of low-level technological integration and they have proved useful in understanding the basics of integration and the problems that can arise. They offer an immediate method of considering technology that can be built upon in the future. A wire in the garment today may become a printed circuit one day. However the routing of a circuit using the construction of the garment is still a relevant skill, as demonstrated in Desiree. The case studies also show that the careful selection of fashion fabrics can enhance the look of material technology. In this way, the case studies act as a template for other practitioners to follow for the low-tech integration of technology with garments.

Extending The Context: Affective Computing

By making new connections between seemingly disparate areas, (body language, affective computing, music, emotion and fashion) Emovere and the Unworn garments crossed the boundaries of design, science and technology thereby making a contribution to all three areas.

Full integration of an affective computing system as an interface to self-expression has not previously been explored in fashion and technology. Several practitioners have made simple correlations between the rhythm of the body and a change in aesthetics but none have attached an emotional value to the output. Emovere extends this research by analyzing the body signals against a series of emotional parameters so that the aesthetic output has an inferred emotional valence.

There is much debate and speculation about the reliability and use of biosignals to determine emotional inference. It has been suggested by Rees and Cass that such

affective computing could become a 'robot poet', a machine that reads and simulates human response but is less interesting as an interface to stimulate 'poetic' dialogue with the user. They propose that within 'Poetic Interfaces', 'the computer remains the tool and people the poets, the ones sharing emotional experience'.[225] However, cannot a 'reader' also become a 'mediator' of emotions? When the AffectiveWare platform relays changes in affect back to the garment, new social interactions may be created through the 'poetics' of an aesthetic vocabulary. Much of affective computing is centred on human computer interaction but by addressing this area from a fashion perspective the emphasis shifted from human-computer interaction to human-human interaction.

This research thereby extended the application of affective computing and increased awareness and relevance of a fashion concept to other technology fields. This is evident in the papers that have been generated by the research and their acceptance to publications that would not ordinarily include fashion practice, such Personal and Ubiquitous Computing and Computers and Graphics.[226]

Extending The Context: Emotional Design

In the Unworn garments, darker emotions are communicated via technology in the domestic environment. So far as I could discover, this is a new setting and context for the merger of fashion and technology. The garment as an unworn object has been used in fine art practice as a statement of an idea, for instance in the work of Caroline

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[225] Fiona Rees and John Cass, 'Poetic Interfaces', in *The New Everyday: Views on Ambient Intelligence*, ed. by Emile Aarts and Stefano Marzano (Rotterdam: 010 Publishers, 2003), pp. 224-229 (p.224-225)

[226] Lisa Stead and others, ' The Emotional Wardrobe', *Personal and Ubiquitous Computing,* 8 (2004), 282-290 and Goulev, P and Stead, L. '*Computer Aided Emotional Fashion*', *Computers and Graphics*, 28 (2004) 657-666.

Broadhead[227] and many other practitioners.[228] Contemporary fashion designers have also used the unworn garment as a way of concentrating attention on the garment concept.[229] However, I did not locate any instances of idea of the domestic lifecycle of an unworn garment that used technology to mediate between people and clothes.

Contribution To The Research Area

The project thus made a specific contribution to knowledge to an emerging research area in its capacity for emotional mediation and its integration of technology. Practice-led fashion and technology research is still a young area which remains largely under-researched in academia. Much of the research to date has been carried out in technological institutes such as MIT, rather than in a fashion institute, although this is slowly changing as technology is becoming part, however small, of the fashion curriculum. As such this thesis acts as an information base and testing ground for other practitioners and subsequent students of fashion and technology. Its context is a mixed arena which includes interaction design, interactive art, dance/ performance and fashion design as opposed to the fashion industry. This context creates very different emphases and outcomes from the context of the fashion industry. This research addresses the practice from a fashion perspective (rather than an interaction design, art or technology viewpoint) bringing fashion thinking, construction techniques and aesthetic experimentation to the forefront.

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[227] Caroline Broadhead, Barrett Marsden Gallery and Mid Pennine Gallery, *Chairoscuro: Caroline Broadhead*, (London : Barrett Marsden Gallery, 2001).
[228] *Addressing the Century: 100 years of Art & Fashion.*,(London: Hayward Gallery,1998)

Recommendations For Future Research

Emovere - Wearer Customisation

A further development for Emovere could be to give the wearer greater autonomy to create her own aesthetic patterns and programs. This could be implemented by using music files to create the lighting display program. The wearer could select a piece of music that has specific emotional connotations and use the rhythm, sound intensity and phrasing to determine the light sequencing display. This would extend the model used in Emovere whereby similar information is used to provide the aesthetic parameters for the lighting display. It would also constitute reverse of the model already implemented by MIT in their Affective DJ concept, where the music in a portable CD player is selected to correspond to the changing emotional state of the user. This idea has already been proposed to Roberto Bresin at the Royal Institute of Technology in Stockholm, who has confirmed that he is developing a piece of software that could be used for such a purpose. He is working on a 'cue extractor' that translates the emotion in a sound file into a moving coloured ball on a screen so this same information could determine a colour change and movement in the garment light sequence.[230]

Emovere - Networked Garments And Downloadable Aesthetics

The next step in this process of customisation could be the introduction of downloadable programs to change the aesthetics of the garment or to devise a piece of accessible software that could be used by the wearer to support their own display

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[229] Issey Miyake has used this technique to great effect in his exhibition at the Cartier Foundation for Contemporary Art.See, Issey Miyake, *Issey Miyake: Making Things*, (Zurich: Scalo,,1999).

[230] See, <http://www.psyk.uu.se/hemsidor/musicpsy/> [accessed 3 March 2005].

designs. The program could be downloaded from a website and delivered to a mobile phone which is used support the garment display (in the same way that the display and emotional information is presently transported from the database at Imperial College to Emovere). The downloadable display information could be shared among friends, via mobile phones building on the cultures already evident within mobile phone culture amongst the young, where new ring tones are downloaded and exchanged (see Context Review). Alternatively, a customized software program could be developed as an extension of Emovere display. It would be as simple to use but with greater choice of colours, colour levels and light placement.

Emovere - User Studies, Design And Evaluation Techniques

Emovere could be evaluated by setting up a series of user studies to ascertain wearer and viewer response to the use of the garment in social interactions. Although this was not achieved within this PhD study such a process could provide valuable feedback from the wearer as to how and when they use the garment and how it could be redesigned. This process could be helped by transferring Emovere technology to more 'usual' looking and wearable garments and giving the prototypes to a group of users to appropriate and to 'play' with. The intention would be to use the garments in everyday situations and for the user group to self-report via diary and questionnaire focusing on their experience of use. The participants would be encouraged to note the different ways in which the visualization of emotions enhanced or worsened social situations, how and when they used the garments and to suggest further developments for the

technology and garment. In this way practitioners would gain valuable feedback on their designs and the wearer would almost become a co-creator. [231]

Emovere - Designing And Enhancing Interaction

When we look at technologically enhanced aesthetics connected to mobile communications, as has been suggested in Emovere, it could also be interesting to consider the garment itself as a mobile communications device (Context Review). Mobile communications provide one of the many modes of 'conversation' that we experience throughout the course of the day; the brain is bombarded by sensory information in addition to new media mediated exchanges between people[232]. When technology is placed within garments to extend it communicative capabilities it needs to fit in with these social dialogues enhancing social situations rather than complicated them. Designing' interactions by first understanding them may provide one way to address this problem.

Interaction designers such as Cute Circuit and Joanna Berzowska have done some of the most interesting work with clothing and technology. Cute Circuits *F+R Hugs,* exploits user studies into body language to inform the placement of the technology, ('a taxonomy of hugs') and to test the prototype garments.[233] Berzowska's multi-disciplinary work on *Expressive Software and Ambient Media*, uses a 'performance research approach' to explore how people express themselves to one another using

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[231] Christina Lindsey, 'Involving People as Co-Creators', in *The New Everyday: Views on Ambient Intelligence*, ed. by Emile Aarts and Stefano Marzano (Rotterdam: 010 Publishers, 2003), pp. 38-41.

[232] The idea of 'modes of conversations' was uncovered in a workshop on Human Connectedness that I attended as part of' The Emotional Wardrobe Cluster' funded by the AHRC/EPSRC Design for the 21stCentury initiative. It took place on the 6th April 2005 at Imperial College London.

sensor garments and video to track movement. The movements are then augmented by sound in an ambient environment that maps gestures to sound creating 'gestural instruments'.[234] These examples provide a template for a new direction for fashion and technology that looks to body language to understand social interactions and then use technology to augment social dynamics as well as ambient technology (Context Review).

A different methodology could be suggested for the marriage of clothing and technology where the emphasis would be on understanding social interactions and using technology to enhance or extend these interactions. A hypothetical question might be "what could my garment do to initiate a conversation on the tube?"[235] This would require a social science approach to research, where social interactions are observed, evaluated and analysed. This information could then be used to map out scenarios of use, which the garments and technological interventions would seek to address. This information would then feed into the prototyping of garments, user studies and an extended iterative design process.

Garment Physicality And Technological Intervention

Donald Norman's recognition that design clues can help product usability highlighted a possible area for future development that marries the physicality of clothing with technological interventions. Instead of adding technology onto the garment to create a

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[233]See http://www.cutecircuit.com/now/projects/wearables/fr-hugs/ for a description of the project.
[234] Sha Xin Wei, and others, 'Demonstrations of Expressive Software and Ambient Media', <http://www.cc.gatech.edu/gvu/people/students/Steven Dow/files/TML-Motes-UbiComp03.pdf > [accessed 28 January 2005].
[235] This idea was raised at The Emotional Wardrobe cluster, Explore workshop held at Imperial College, see <http://www.emotionalwardrobe.com> [accessed 8 July 2005]

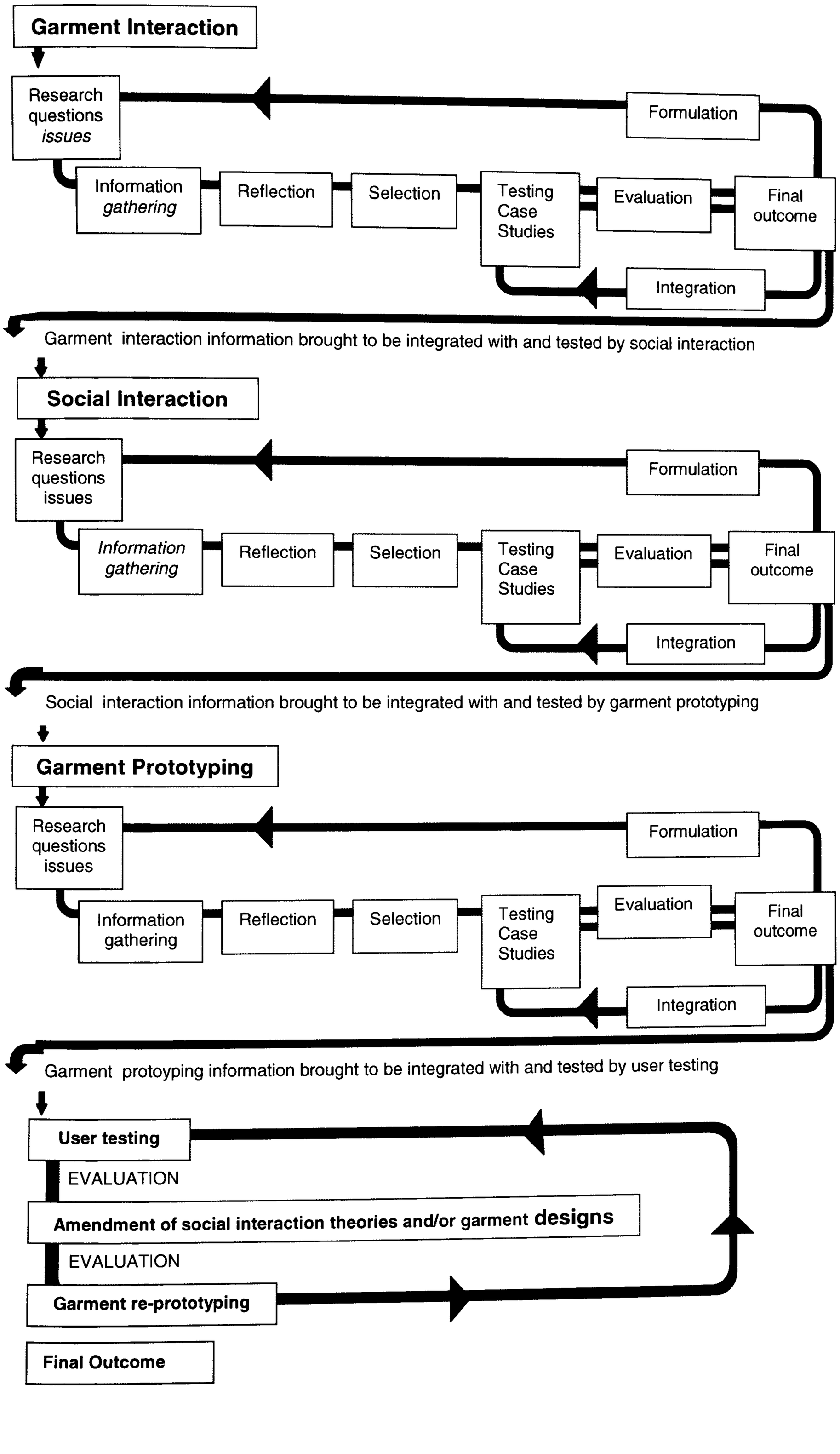
responsive aesthetic, technology could be used to enhance the physical aesthetics of traditional garments. Construction devices such as flaps and strips, as in the experiments, or pockets and zips could form switches so that moving or interacting with the garment in an intuitive manner would stimulate or control the technology.

In addition, decorative textile devices such as pleats could become active through perhaps Shape Memory Alloys (see Cute Circuit's Accessory Nerve in Practice Review). When an interaction is stimulated within the garment, the textile foundation of the garment could move rather than a light being triggered. This mixture of low and high tech interaction would make the interaction of the wearer with the garment intuitive. Based on the natural way that people interact with their garments the actuation within the garment would be everyday and softer.

The Extended Fashion Design Process

The fashion design process has future potential to integrate other forms of research methodology. The elements of social and garment interaction, user evaluation and an iterative design process can be applied to the research process as outlined in the methodology to create an extended fashion design process (Fig.5. 1). In the first phase of the macro research process, information is gathered about theories of social interaction. These are selected and tested against actual social interaction observed in naturalistic settings or via role-play. This information is then evaluated to gain insights about behaviour in social situations. The findings might generate further social interaction questions or issues to be researched, tested and evaluated or become the inspiration for garment developments, (see Macro View). The social interaction information is then taken to the garment interaction phase of the iteration where it is used to inform the garment interaction developments (three-dimensional material

Fig. 5. 1. The Extended Fashion Design Process



developments and intuitive studies of wearer interaction with garments). Again the outcomes of the garment interaction phase are taken to inform the development of the garment prototypes through the macro and micro fashion design process. The garment interaction and prototype stages of the iterations may be performed many times to include material, technology and design considerations.

Once the iterations of the macro and micro fashion research process (see diagram in Introduction) have been completed and garment prototypes have been developed, they are taken forward for user testing. The results of the user testing are evaluated and inform social interaction theories and or garment interaction and garment prototyping. This information informs the re prototyping of the garment. The iterations of user testing, evaluation, amendment of information and garment re prototyping are performed until a suitable end result is accomplished.

Emovere - The Application Of Affective Computing For Therapeutic Benefit

An area that I would be very interested in researching and developing in the future would be the use of Emovere idea as a tool for teaching emotional recognition to autistic children, or as an aid to communication for mentally disabled children or stroke victims that have lost the ability to verbalise their emotions. This is an idea that has been considered by looking at research conducted at MIT by Katherine Howard Blocher at MIT (Context Review) and Simon Baron-Cohen and his team at the Autism Research Centre at the University of Cambridge in England.[236] It is also a concept that was proposed and discussed on numerous occasions with members of the public

during my seminars and with friends and family who have disabled and autistic children. [237]

A similar system to the Affectiveware platform in Emovere would be developed to teach emotional recognition and empathy to autistic children. The garment could be used in role-play situations or worn by the children themselves or their helpers to create an awareness of the appropriate emotional responses in social situations. This concept could also be developed as a communicative device for stroke victims who are no longer able to speak. A simple colour coded display of emotions could help carers, nurses and relatives to understand the emotional wellbeing of the patient quickly and effectively.

This concept would require the development of a fully integrated sensory and display garment which is a soft and durable interface and in the case of autistic children, in an unbreakable format. The efficiency of the AffectiveWare platform would need to be developed as emotional recognition via affective computing is still in its infancy and not reliable enough to guarantee completely accurate results. Expert collaboration would be required with autism specialists to guide and inform the research. [238]

It would be interesting to explore the therapeutic possibilities of a garment that can

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[236] The Autism Research Centre at the University of Cambridge, <http://www.autismresearchcentre.com/arc/default.asp> [accessed 14 January 2005]

[237] Autistic children have problems socializing because they have difficulties recognizing emotions in others, showing empathy and communicating their own emotional state.

[238] I am currently proposing a collaborative project in which Imperial College would provide and develop the Affectiveware platform and I would develop and implement the concept and garment. To help with this task I have made contact with a group from the University of Pisa who have developed a soft sensory garment for mobile health monitoring (see Wealthy - <http://www.wealthy-ist.com> [accessed 25 October 2005]) and who are have an associated department that works with creating computer animated facial expressions of emotion who may also be interested in collaborating in an emotional therapeutic or teaching system. The Autism Research Centre at the University of Cambridge or The National Autistic Society in London could also be approached for specialist knowledge.

measure and display emotions and to use the developed technology of Emovere for a functional and useful purpose. This development could also signal the route for the development and application of technology in clothing, where the technology is developed first for healthcare or sports applications and later becomes acceptable for more mainstream or fashion applications.

Issues Raised

The recommendations for future research have emerged specifically from my practice and research process. They raise bigger questions about how the fashion and technology industries might develop in tandem, how a fashion and technology merger might be defined and whether the fashion industry would embrace this change. This in turn, might have consequences for the role of the fashion designer in this growing and collaborative field.[239]

Timing, Technique - Can Fashion And Technology Merge In The Real World?

The integration of fashion and technology calls for a longer development time line than traditional fashion practice. In fashion it is usual to create a seasonal collection but the addition and development of technology means that a design could take a year or years to create. If a fashion and technology merger is to be successfully managed, a

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[239] Although, many of the points are speculative, as there is little evidence, I feel it is important to raise these issues for future research.

rationalization of time frames is needed, to correlate the flux and speed of fashion with the longer development time of technology. This would require the selling seasons of fashion to lengthen, or become non-seasonal or for a hybrid sub-section of fashion to be developed, that is not constrained by the usual rapid turnover of styles associated with fashion, as reiterated by Clive an Heerden, 'The two industries will need to find a modus vivendi that accommodates or resolves the different speeds of their markets.[240]

This concern is reflected in a seminar given by Polly Duplock at the Avantex Symposium in June 2005. In her paper 'Hybrid Working Practices between Fashion and Product Design', she contrasts the 'rigorous iterative analytical' product design process with the shorter leadtimes in fashion .[241] She understands that the iterative process maintained in product design is to alleviate risk and unnecessary costs from the product development cycle and that in comparison the fashion industry has a relatively short development time. However, if it is accepted that the introduction of some electronic and material technologies within clothing will create a hybrid electronic product/garment it might mean adopting some aspects of the product design process, such as increased development time to allow for the improvement, testing and production of technology within the garment. As Sabrina Tanner stated at Avantex, 'Product design is not surface design, it goes much deeper and should be one part of the whole development process'.[242]

For fashion and technology to unite, a meeting of construction technology that

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[240] Clive Van Heerden, 'Selling Wearables', in *The New Everyday: Views on Ambient Intelligence*, ed. by Emile Aarts and Stefano Marzano (Potterdam: 010 Publishers, 2003), pp. 178-281

[241] Duplock approaches the problem from the other viewpoint, stating that product design should look to fashion to understand the integration of soft technologies within the product design process and its emotional context but she recognizes that the product design process is still necessary to accommodate the needs of technology. See Polly Duplock, 'Hybrid Working Practices between Fashion and Product Design', Avantex Symposium, June, 2005

accommodates both garment construction and electronic production would be necessary. Until electronic components and material technology can be purchased on a roll and processed as fabric, it is unlikely that this merger will happen in a mass-produced scale. However, the lifting of import embargoes, under The Multi-Fibre Agreement might stimulate the European textile industry to push development of technology enhanced clothing and textile technology.

Fashion and technology could be initiated in several ways. Firstly, researchers could continue to investigate this area where longer development times can be accommodated. The area would remain research, until such time as material and electronic technologies become soft fabrication. Or perhaps a merger of fashion and technology could exist in small quantities, at luxury high fashion level, where development times and additional costs would be relatively inconsequential. In this capacity, technology driven aesthetics could be used to tantalize the customer and provide added value and exclusivity [243]. Alternatively, fashion and technology might develop as a hybrid area that borrows product development methodology from performance and health care clothing, aesthetic sensibility from fashion, and uses market positioning knowledge from the sportswear industry.

Sabrina Tanner states that, 'It is an illusion that there will be a separated market for wearables'.[244] It is too early to tell but in principle I disagree as the only evidence of technology filtering through from research into mainstream clothing has happened in the sports/ casualwear industry (Context Review). A hybrid urbansports/ fashion

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[242] Tanner, S and Herwig, A. 'Designing the future – Ways to make wearable products marketable', Avantex Symposium, June, 2005.
[243] Clive van Heerden, looks at this possibility from the point of view of the electronics industry. He recognizes that the integrations of soft electronics within the luxury fashion market could offer greater revenues for the electronic industry, in a climate which sees the industry fighting a 'perpetual price erosion'. In this way the merger could be beneficial for both markets by creating added value to both products. Clive van Heerden, p 280

technology market might emerge that introduces mobile phone capabilities. A younger teen market might more readily adopt downloadable aesthetics and capabilities to create social gaming scenarios and playful customization.[245]

Definition – Will It Be Called Fashion?

If the essence of fashion is changing style and the exploitation of shape and pattern, can technology-enhanced garments ever be 'fashion'? At present technology takes time to develop and the look of a garment can be spoiled by the limitations of the technology but these are only issues in the short term. Once of-the-shelf electronic material technologies become available and can be integrated using traditional fashion manufacturing processes then the merger of fashion and electronic and material technology could be the ultimate fashion vehicle: changing styles at the flick of a switch.

Many of the designers in the Practice Review call their work fashion and recognize the importance of its heritage for the acceptability and development of wearable technology. Berzowska states 'The real killer app for wearable computing is to convey personal identity information – this is called fashion, and it's mostly visual.'[246] But for fashion to integrate technology successfully it needs to remember its function as a communicator of identity via aesthetics and not fall into the trap of using garments to carry technological function as has been seen in the past from technology companies

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[244] Tanner, S and Herwig, A. 2005

[245] See the Equator research project who have exploited mobile phone capabilities and inadequacies to create 'seamful' social gaming. Equator, Seamful Games <http://www.equator.ac.uk/index.php/articles/c93/> [accessed 5 February 2005] and M. Chalmers and others, 'Seamful Design: Showing the Seams in Wearable Computing', *IEE Eurowearable '03*, (2003), 11-16.

such as Pioneer, with their computer display in a sleeve[247] and as shown in Chanel's tv-in a belt, shown on the catwalk for Spring/ Summer 2005 (Fig.5. 2.).[248] As Despina Papadopolous of 50:50 asserts:

> The idea of an email projected on its sleeve, or a t-shirt that reads all your signs is so radically foreign to our perception of what it is to be a person. It is also quite divorced from the aesthetics, and political nuances of clothing. If we get our way it will be about imagination, self-expression, and most importantly, inspiration.[249]

Fig.5. 4.
Chanel's *TV Belt* (2005), why would you want a screen in your belt when you cannot see it yourself? Fashion should not follow this direction if wearable technology is to be seen as 'fashion'. It ignores all the conventions of fashion for geek chic!
Source:
tp://www.purseblog.com/accessories/chanel-tvbelt/

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[246] Joanna Berzowska, 'Intimate Electronics, Wearable Computers, Electronic Textiles, and Reactive Fashion', *HorizonZero*, Issue 16:WEAR, July (2004) <http://www.horizonzero.ca/textsite/phprint.php> [accessed 11 December 2004]
[247] See 14U, <http://www.i4u.com/article407.html> [accessed 22 October 2003]
[248] See The Purse Blog <http://www.purseblog.com/accessories/chanel-tv-belt/> [accessed 2 July 2005]

Does Fashion Want Technology?

There appear to be many barriers to the integration of technology within fashion. The development times are too problematic and there is currently a lack of soft, simple and reliable technology to integrate. Does fashion really want technology? It is telling that there are few fashion designers exploring the possibilities of technology and that fashion designers such as Chalayan produce 'conversation pieces' rather than saleable products integrating technology. Many fashion designers have made the transition from material technology research to product such as Miyake with his A-POC range, Elisabeth de Sennville, C.P.Company and François Girbaud who was one of the first couture designers to use laser cutting and welding in high tech polyester garment construction. However these garments do not employ any electronic functionality and Miyake's A-POC range offers the consumer a low-tech level of customization. Hindered by technical constraints and a lack of truly integrated soft technology, perhaps it is not surprising that the fashion industry is yet to capitalize on this new market. Perhaps these factors also mask a lack of interest in the area.

At the Fashion and Lifestyle lectures at Avantex Symposium in 2005, the chair asked for members of the fashion industry to come forward to pass an opinion on technology and fashion. Only one person from the fashion industry stood up and expressed an interest and she was a representative from Sara Lee, a major American conglomerate that has recently established a research department in the UK. The journalists who showed interest in the research on the Central Saint Martins College of Art and Design stand at Avantex were from textile publications rather than from fashion publications. One fashion journalist, from *Womenswear Daily,* did show interest but it was in what she described as the beautiful shape of Desiree and the appeal of Icaris. Both of these

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[249] Katherine Moriwaki, 'The Future of Wearables', *Art + Text*, August (2002) <http://rhizome.org/thread.rhiz?thread=3467&text=6284> [accessed 22 May 2005]

garments can be read as normal wearable garments without the addition of technology. The journalist seemed unimpressed by the concept of Emovere, which admittedly looks otherworldly and unconventional. As the case studies show, until technology can be presented aesthetically on a level with traditional fashion, the fashion industry is unlikely to be engaged by wearable technology. Perhaps technology needs to be instigated by accessible ideas and aesthetics from academic research and very 'wearable' technical solutions from the technology and electronics sectors before fashion will accept technology as a viable proposition. But if this acceptance occurs what could this mean for a new generation of designers working in this field?

The Role Of The Designer Extended

Throughout the study I have realised that I still do not feel like a specialist within an area that does not actually exist as a formed discipline and seems to involve a mixture of different approaches that include interaction design, product design, performance art, electronics and computing. To work in this field requires one to embrace and understand many types of information and methodologies in order to produce a single garment. An understanding of garment construction and clothing on the body are as essential as an understanding of electronics and material technology. Practitioners must be willing to embrace both fashion and technology. If the practitioner is content to use technology to materialize ideas and hand over the making and realization of the idea to technically qualified professionals, less knowledge is required and a new role for a technical implementer who works alongside the designer might be appropriate. However, if the research and understanding of technology is used to inform designs and concepts, then greater interaction with the technology is required. This could have implications for the education of future fashion designers who might be required to be

multi-skilled in fashion, electronics and computing.

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